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SOLAR HEAT—ITS INFLUENCE ON THE EARTH'S ROTARY VELOCITY.

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From "Engineering."

(*See Frontispiece.*)

Laplace's demonstration showing that the axial rotation of the earth is not affected by atmospheric currents and similar motions caused by solar heat, has been accepted by physicists as incontrovertible. The German mathematician, Dr. Mayer—celebrated for his demonstration establishing the equivalent of heat—says in a discourse on that branch of celestial mechanics which relates to the effect produced by contrary atmospheric currents: "The final result of the action of these opposed influences is, as regards the rotation of the earth, according to well-known mechanical principles=0; for these currents counteract each other, and therefore cannot exert the least influence on the axial rotation of the earth. This important conclusion was proved by Laplace." "The same" he adds, "holds good for every imaginable action which is caused by the radiant heat of the sun, or by the heat which reaches the surface from the earth's interior, whether the action be in the air, in the water, or on the land. The effect of every single motion produced by these means on the rotation of the globe, is exactly compensated by the effect of another motion in an opposite direction; so that the resultant of all these motions is, as far as axial rotation of the globe is concerned = 0." I propose to show that this conclusion is fallacious, and that the sun's radiant heat develops forces capable of diminishing perceptibly the earth's rotary velocity. And that unless the retarding influences of solar heat, the existence of which I am going to establish, are counteracted by some cosmical force of which we have no knowledge, the earth's rotary velocity will be considerably reduced in the course of time.

There are two classes of force produced by solar heat, capable of retarding the axial rotation, differing, however, entirely as regards ultimate results. The first class includes animate exertion, mechanical force produced by heat developed by the combustion of organic substances, and the resistance of abraded solid matter transferred from its original position, by the waters of rivers flowing towards the equator. The forces thus enumerated, it will be shown, retard the rotary velocity of the globe in all cases when they remove weight to a greater distance from the axis of rotation, *i.e.*, expand the circle of gyration, thereby diminishing the number of revolutions performed in a

given time, Obviously the vis viva of the rotating mass will remain undiminished, as the centre of gyration is merely removed to a greater distance from the axis of rotation. Accordingly, the axial rotation, though checked, can never be stopped by the class of retarding influences thus pointed out. The second class, however, which comprises the retardation produced by the atmospheric air during its course from the polar to the equatorial regions; and the retardation caused by the waters which flow towards the equator to restore the quantity lost by the powerful evaporation within the tropics, not only diminishes the rotary velocity, but, at the same time, deprives the earth of so great an amount of vis viva, that the axial rotation must ultimately cease, unless some exterior compensating force exists, a supposition at variance with the principles of mechanics.

Let us now briefly examine the nature of the retarding influences of the first-named class, which, as stated, are unattended by any loss of the earth's vis viva, namely, animate force and mechanical energy, resulting from the combustion of organic substances when expended in raising weight to remain permanently in an elevated position; and the retardation caused by solid matter carried towards the equator. Before entering on this examination, it will be instructive to test by some familiar illustration, the correctness of the assumption that "every imaginable action affecting the rotation of the globe, is exactly compensated by the effect of another motion in an opposite direction." A great variety of instances might be mentioned in which the development of mechanical energy, productive of heat, counteracts the rotary motion of the earth, and deprives it permanently of a certain amount of vis viva. Suppose, for instance, a locomotive train weighing 400 tons, to be started from the western terminus of a railway running from west to east. Suppose also that when this train has acquired a velocity of 50 ft. per second, it encounters another similar train which is at rest. The result of such an encounter, in a dynamic point of view, is now well understood. Apart from a small amount of energy absorbed in overcoming the cohesive force of the materials fractured by the concussion, the encounter will develop an amount of heat corresponding with the vis viva of the arrested train. It scarcely needs explanation that in putting the train in motion from the terminus eastward, the rails, *i.e.*, the surface of the earth, will, in consequence of the adhesion between the wheels and the rail, be pushed westward; hence in a direction contrary to the earth's rotation. The amount of dynamic energy which the train thus imparts to the earth in an opposite direction to that of rotation, may be readily ascertained by multiplying the arrested weight by the height necessary to produce a velocity of 50 ft. per second, namely, 39 ft.; hence $400 \times 2240 \times 39 = 34{,}944{,}000$ foot-pounds. Deducting the small amount of energy which favors the earth's rotation called forth by the rolling friction and adhesion of the wheels of the stationary train, during the short retrograde motion attending the concussion, it will be found that the earth loses an amount of vis viva of 34,000,000 foot-pounds. The assumption of Dr. Mayer, based on the theory of Laplace, that the resultant of all imaginable motions as regards the earth's axial rotation, is $=0$, we have thus proved to be untenable. It is not intended to question Laplace's conclusion as regards the existence of a compensating effect; he was mistaken only as to its nature, a mistake, however, of paramount importance, as we have shown that the compensation for the lost energy, in the case presented, is merely the generation of a certain amount of heat which in less than three hours after the concussion, if the sky be clear, radiates into space, leaving the earth minus 34,000,000 foot-pounds of vis viva. Lest the circumstance should be overlooked, it will be well to call attention to the fact, that the retardation thus established is the result of solar energy stored in the combustibles of the locomotive furnace. Numerous other instances might be mentioned in support of the assertion that the earth is subjected to retarding influences and loss of vis viva, by mechanical motions on the earth's surface which result in the production of heat. But all these are insignificant compared with the stupendous amount of retardation caused by the conversion of mechanical energy into heat, within the atmospheric currents circulating between the equatorial and polar regions. In connection with this fact, it will not be out of place to remark, that

our knowledge of the convertibility of mechanical energy and heat—in other words, the convertibility of mechanical and molecular energy—has completely upset Laplace's illusory demonstration on which physicists have based their assumption that the rotary velocity of the earth cannot be affected by the sun's radiant heat.

Let us now examine, separately, those forces produced by solar heat which tend to check the earth's rotary velocity by removing weight from the axis of rotation, *i.e.*, expanding the circle of gyration, and those which occasion a diminution of the rate of axial rotation without disturbing the balance of the rotating mass. The first class: Animate or muscular energy, and the force generated by heat from the combustion of organic matter, controlled by the human mind, both resulting indirectly from the sun's radiant heat. That the hand and intellect of man have caused a disturbance of the position of the earth's centre of gyration, will be deemed a startling assertion; yet it cannot be controverted in view of the following facts. The millions of tons of matter contained in the Pyramids, removed to a greater distance from the axis of rotation by the muscular exertion of the ancient Egyptians, disturbed the previous balance of the rotating mass, causing a tendency to check the earth's rotary velocity, and to increase the length of day. Nor can it be questioned that if London had not been built, and if the building materials of Paris yet remained in the Catacombs, the sun would rise earlier than it now does, though the difference would be small beyond computation. The aggregate of the weight removed from below, and piled above the crust of the globe by the hand of man, is, however so great, that figures are competent to express the extent of the consequent retardation of the axial rotation, while the divisions of our common instruments for measuring distance are sufficiently minute to indicate the expansion of the earth's circle of gyration, caused by the transfer of matter under consideration. A first-class modern city, for instance, contains upwards of 100,000 houses; each house weighs on an average 400 tons, hence the total weight removed from below the surface to a considerable height above the earth, exceeds 40,000,000 tons, a mere fraction compared with the weight of the whole of human habitations and other structures raised above the surface of the earth by human effort, besides the weight of minerals which, during centuries, has been removed to an increased distance from the axis of rotation, by animate exertion and by mechanical force controlled by intellect.

An element of greater importance, connected with the first class of retarding influences, produced by the sun's radiant heat, next claims our attention, namely: the solid and sedimentary matter detached by the abrasion of rain water and afterwards conveyed by the currents of certain rivers, to a position nearer the equator; hence removed to a greater distance from the axis of rotation. The question whether any estimate can be made of the aggregate weight of matter, the original position of which is being changed during definite periods, by the cause referred to, is by no means so difficult to answer as might appear without due consideration. It is true, we do not know what quantity of water or sediment is carried towards the equator by the several rivers; but we can compute with sufficient exactness the extent of the river basins. Accordingly, if we could establish a mean of discharge per square mile of some very extensive basin comprising all the varieties of climate and soil, the question could be satisfactorily answered. Fortunately one of the longest rivers on the globe, the Mississippi, which drains the greatest extent of surface with but one important exception, has been carefully surveyed by a corps of Topographical Engineers, under the direction of General Humphreys, by order of the United States Government. Not only has this great river been thus carefully examined, but its basin comprises every variety of soil and climate, its source being among snows, and lakes frozen during a greater portion of the year, while the outlet is near the tropics. How completely the Mississippi basin represents the average of the river systems of both hemispheres will be understood from this fact, that although the rain gauges at its northern extremities show only 13 in. for twelve months, those of the southern extremity reach 66 in.; with every possible gradation of precipitation in the intermediate space. In addition to this important circumstance, the basin covers 21 deg. of latitude and 35 deg. of

longitude, or 1,460 miles by 1,730 miles; hence comprising an area greater than the entire European Continent west of the rivers Vistula and Pruth. It may be confidently assumed, therefore, that the Mississippi basin represents the average discharge of water and sediment so nearly that calculations based thereon, applied to the river systems of both hemispheres —excepting some of the northern Asiatic and American rivers—will exhibit a general result differing but slightly from what would be established if all the rivers had been examined.

The elaborate report of General Humphreys to the Bureau of Topographical Engineers, Washington, shows that the average quantity of earthy matter carried into the Gulf of Mexico, partly suspended in the water and partly pushed along the bottom of the river by the current, amounts for each twelve months to 903,100 millions of pounds. This enormous weight of matter is contributed by numerous large branches and upwards of 1,000 small tributaries. The main distance along the streams, which the sediment is carried in its course to the sea, exceeds 1,500 miles. The distance which determines the amount of force tending to check the earth's rotation, is obviously shorter.

The maps of the Mississippi river basin accompanying General Humphreys' report, show that its centre is situated 7 deg. 10 min. west of the mouth of the main river, and 11 deg. 15 min. north of the same, in latitude 40 deg. 15 min. It will be found on inspecting the accompanying section of the earth, that agreeable to the stated latitudes, the centre of the Mississippi basin rotates in a circle of 15,784-782 ft. radius, and that its velocity round the axis of the globe is 1,147.90 ft. per second. The mouth of the river, it will also be seen, rotates in a circle of 18,246-102 ft. radius, with a circumferential velocity of 1,326.89 ft. per second. Comparing these velocities we ascertain that an increased circumferential velocity of 178. 99, say 179 ft. per second, is imparted to the water and to the sedimentary matter which it conveys during the course from the centre of the basin to the mouth of the river. As before stated, the annual discharge of earthy matter at the mouth of the river is 903,100 millions of pounds. The centre of the basin, lat. 40 deg. 15 min., being 2,461,320 ft. nearer to the axis of rotation than the mouth of the river in lat. 29 deg. 0 min., it will be found that the increase of rotary velocity as already stated is 179 ft. per second—a rate acquired by a fall of 500.6 ft. The elements are thus furnished for determining with exactness, the amount of retardation attending the change of position of the abraded matter during its transfer from the basin to the mouth of the river. Multiplying 903,100 millions by 500.6 we ascertain that the counteracting force exceeds 452,000,000,000,000 foot-pounds annually $= 452 \times 10^{14}$ foot-pounds in a century. The earth's present vis viva being $18{,}875{,}361 \times 10^{22}$ foot-pounds (to be demonstrated at the proper time), it is easy to calculate that the retardation occasioned by the stated reacting energy called forth by the sedimentary matter which is carried to the ocean by the Mississippi, will amount to $\frac{36}{100000}$ of a second in a century. In view of this small fraction of time, it will be well to remind the reader that the retardation of the earth's rotary velocity, inferred from the apparent acceleration of the moon's mean motion, now generally admitted by astronomers, is somewhat under 12 seconds in a century. Insignificant as this retardation appears to be, it calls for a constant reacting force of 4,55-000,000,000 foot-pounds per second, as will be shown in the course of our investigation. Dividing this amount by the adopted standard of a horse power, viz., 550 foot-pounds per second, it will be found that a constant energy represented by 827,000,000 horse power, exerted in a contrary direction to that of rotation, is necessary to check the rotary motion to the extent mentioned, viz., $\frac{12}{864000} = \frac{1}{72000}$ of a revolution in the course of a century. Accordingly, 720,000 years, nearly, will elapse before one entire revolution shall have been lost, notwithstanding the existence of a constantly retarding force of 455,000 millions of foot-pounds per second. We can readily ascertain the aggregate of this force during the long period mentioned, if we multiply the same by the number of revolutions of the earth per annum, and the number of seconds for each revolution; thus, $455 \times 10^9 \times 365.24 \times 86{,}400 \times 720{,}000 = 103{,}379{,}867 \times 10^{17}$ foot-pounds. By dividing this amount of energy in the earth's vis viva, $18{,}875{,}361 \times 10^{22}$ foot-pounds, we ascer-

tain that the stated enormous retardation overcome in the course of 720,000 years, amounts to only $\frac{1}{18138}$ of the present rotary vis viva of our planet. Probably no other mode of presenting the subject could give so clear an idea of the vastness of the mechanical energy of a sphere 8,000 miles in diameter, whose specific gravity is 2¼ times that of granite, revolving at a rate of one revolution in 24 hours. Returning to the retardation produced by the Mississippi, let us bear in mind that the precipitation which causes the abrasion of the solid matter and the currents by which it is conveyed is the direct result of the sun's radiant heat.

With reference to the Tables given on pages 116 and 117, it should be stated, that the amounts of the retarding force entered in the last two columns, are based on the data furnished by the examinations of the great Western river, viz. : that 1 lb. of solid matter and 1,350 lbs. of water, per second, are carried to the sea for every 40.08 sq. miles of basin. All other particulars necessary in computing the retarding energy exerted by each river, separately for the two hemispheres, will be found in the Tables. The mode adopted in determining the area drained by each river and tributaries, will be readily comprehended by the following explanation. The extent of the several river basins, 136 in all in both hemispheres, have been ascertained from the best maps extant ; the boundaries of the basin being determined by drawing a line on the map dividing the territory equally between the source of each river and tributaries, and those of adjoining basins. The boundaries being thus defined, the areas have been calculated in English statute miles ; the latitude and longitude of the centre of each basin being determined at the same time. By supposing the earth to be a perfect sphere 7,912.41 miles in diameter, according to Sir John Herschel's determination, the calculations have been rendered extremely simple. This will be seen by reference to the annexed section of the earth, which contains all the elements for computing the rotary velocity of the centres of the river basins, and of the outlets of the rivers. These velocities have been entered in the Tables, separately for each river basin; also the retardation, expressed in foot-pounds per second, caused by the increase of rotary velocity during the transfer of the sedimentary matter from the centre of the basin to the mouth of the river. The last column of the Tables contains the result of computations of the amount of retardation occasioned by the volume of water which conveys the sedimentary matter, a subject to be considered under a separate head hereafter.

It should be observed, that owing to their trifling influence on the earth's rotation, and in order to save space, all the English and Scotch river basins whose sediment is transferred in the direction of the equator, have been entered together in the Tables ; the rivers of Ireland likewise. But in computing the loss or gain of energy, each river basin has been calculated by itself ; the amount of retardation entered being the result of the whole quantity of sediment transferred towards the equator by the several small basins referred to. Accordingly, the area which is entered in the Table, represents the total. The river basins of Sweden and Norway being very numerous and unimportant, have also, in some districts, been entered together in the Tables like those of Great Britain. Finally, the narrow coast districts, in both hemispheres, have been computed and entered in the Table in a similar manner. See Tables on page 342.

The quantities of sedimentary matter discharged by the Indus, Ganges and Brahmapootra, being known with tolerable accuracy from actual observation, have not been computed according to the standard furnished by the Mississippi, which, as before stated, is 1 lb. of sediment per second for every 40.08 sq. miles of basin. Besides, local circumstances, such as the heated waters and profuse evaporation of the Bay of Bengal, and the powerful condensation attending the close vicinity of the Himalaya Mountains, render the Ganges quite exceptional.

[TO BE CONTINUED.]

PRACTICAL engineers about New York are much exercised by the reputed performance of Paine's Electro-Magnetic Engine at Newark. It apparently does the work of a 2-horse power engine, though driven by only three Bunsen battery cups. Many electricians believe in it. Engineers naturally doubt it.

RIVERS FLOWING TOWARDS THE EQUATOR. (*See "Solar Heat," page* 337.)

NAME OF RIVER OR DISTRICT	River Basin.								Mouth of River.				Retardation.	
	Area.	Latitude of centre.		East of outlet.		West of outlet.		Rotary velocity.	Latitude.		Rotary velocity.	Incr. of velocity	By Sediment.	By Water.
	Square miles.	Deg.	M.	Deg.	M.	Deg.	M.	Feet per second.	Deg.	M.	Feet per sec'd.	Feet per sec'd.	Foot-pounds per sec'd.	Foot-pounds per second.
EASTERN HEMISPHERE.														
Anadir	119 200	65	50	..	..	1	35	622	64	30	654	32	47 680	64 368 000
Rivers, N. W. coast Sea of Kamtschatka	52 000	61	42	..	10	..	..	720	60	45	742	22	9,828	13 267 800
Penshina	50 100	63	20	..	20	..	..	681	61	46	719	38	28,256	38 145 600
Rivers, west coast Sea of Okhotsk	32 600	62	00	..	..	..	05	713	61	20	729	16	3 260	4 401 000
Yama	15 500	60	45	..	..	1	30	742	59	40	767	25	3 786	5 111 100
Tawi and Kowa	13 300	60	25	..	..	..	10	750	59	40	767	17	1 503	2 029 050
Ochola	21 500	60	48	..	..	..	40	741	59	45	765	24	4 838	6 531 300
Ud	25 400	55	25	..	..	2	35	862	55	20	864	2	40	54 000
Toumen	20 000	43	20	..	..	..	15	1105	42	55	1112	7	385	519.700
Yaloo	21.200	41	10	1	05	..	..	1144	40	10	1161	17	2 396	3 234 600
Sira Muren	78 700	42	40	..	..	1	06	1117	40	50	1149	32	31 480	42 498 000
Chanton	29 800	41	00	..	..	..	30	1146	39	10	1178	32	11 920	16 092 000
Pei-ho	124 000	38	40	.	..	2	45	1186	38	25	1187	1	48	64 800
Min Kiang	25 400	26.	20	..	..	1	15	1362	26	00	1364	2	40	54 000
Han Kiang	26 200	24	18	..	05	..	..	1384	23	20	1395	13	173	233 550
Tche Kiang	144 400	24	10	..	..	3	50	1386	22	53	1399	13	9 530	12 865 500
Hoang Ho	448 200	36	50	..	..	10	25	1216	33	45	1263	47	386,797	522 175 950
Sang Koi	76 300	22	40	..	..	2	28	1402	20	32	1423	21	13,143	17 743 050
Coast Rivers, Gulf of Tonquin	26 000	20	12	..	..	1	50	1426	20	00	1427	1	10	13.500
Menam Kong	329 500	16	38	..	..	3	15	1455	10	05	1496	41	216 399	292,138,650
Irawady	205 000	22	35	..	..	..	30	1403	16	10	1459	56	251 125	339 018.750
Brahmapootra	379 000	29	12	1	05	..	..	1326	22	00	1408	82	5 187.040	7 002 504 000
Ganges above Ghazepoor	187 100	27	25	..	..	5	25	1346	22	00	1408	62	1 463 818	1.976 154 300
Ganges below Ghazepoor	237 200	27	30	..	..	5	12	1347	22	00	1408	61	2 694,633	3 637 754,550
Khaladaing	27 400	21	15	..	..	..	20	1416	20	30	1423	7	527	711 450
Braming and Coyle	31.000	22	12	..	..	1	26	1406	21	15	1416	10	1,209	1 632,150
Mahanuddy	41.300	21	02	..	..	3	55	1418	20	28	1423	5	403	544,050
Rivers N. W. coast of Bay of Bengal	24 000	19	15	..	..	..	32	1434	18	20	1442	8	600	810 000
Godavery	133.000	19	35	..	..	3	25	1431	16	50	1454	23	27 498	37.122.300
Kishna	104 900	16	45	..	..	4	35	1455	16	10	1459	4	656	885 600
Rivers west coast Bay of Bengal	8.300	15	45	..	..	..	18	1462	15	30	1464	2	13	17 550
Penaur	17.900	14	45	..	..	1	30	1469	14	35	1470	1	7	9 450

Palar	23 700	12	52	..	..	1	20	1481	12	40	1482	1	9	12 150
Canvery	25 000	11	45	..	..	1	53	1487	10	55	1492	5	244	329 400
Tapty	23 600	21	15	2	50	..	..	1416	21	10	1417	1	9	12 150
Nurbudda	21 600	22	14	3	45	..	..	1406	21	48	1410	4	135	182 250
Sukernully	29.700	23	27	..	25	..	..	1394	22	30	1403	9	943	1 273 050
Jahu	48 300	26	25	2	20	..	..	1360	24	52	1378	18	6,110	8.248,500
Indus	346 300	33	30	5	20	..	..	1267	24	00	1388	121	5 140 969	6.940 308 150
Helmund	124 000	32	42	3	25	..	..	1278	31	52	1290	12	6 975	9 416 250
Northern coast of Arabian Sea	93,000	26	30	1	00	..	..	1359	25	15	1374	15	8 184	11 048 400
North-east coast of Persian Gulf	66 000	29	00	..	45	.	..	1329	27	50	1343	14	5 049	6 816 150
Southern coast of Arabia	96 000	15	20	..	..	..	50	1465	13	50	1475	10	3 744	5,054,400
Euphrates and Tigris	282 100	35	05	..	..	4	35	1243	30	05	1314	71	555 525	749,958 750
Kour	95 400	39	55	..	..	3	32	1165	39	52	1166	1	37	49 950
Oural	126 300	50	04	2	01	..	..	975	47	02	1035	60	177 609	239.772 150
Don	195 400	48	56	1	48	..	..	998	47	06	1034	39	98 921	133,543 350
Emba district	37,800	47	50	3	00	..	.	1020	46	50	1039	19	5 330	7.195.500
Volga	557 700	55	00	..	..	..	10	871	46	10	1052	181	7 137,026	9 634 985 100
Kuban	34 600	44	50	2	55	..	..	1077	44	42	1080	3	121	163.350
Rioni	17 900	42	38	..	50	..	..	1118	42	15	1124	6	251	338 850
Syrian Mediterranean rivers	8 800	33	40	1	10	..	..	1265	33	22	1268	3	30	40 500
Jordan district	12 400	32	20	..	35	..	..	1285	31	48	1290	5	121	163.350
Schoon	12 000	47	40	..	15	..	..	1023	46	45	1041	18	1 518	2 049 300
Axon and others	23 600	47	32	2	00	..	..	1020	46	40	1042	16	2 360	3 186 000
Minder	9 900	47	40	1	35	..	..	1023	47	30	1026	3	35	47 250
Sarabat	8 300	48	22	1	15	..	..	1009	48	18	1010	1	3	4 050
Dnieper	181.000	51	25	..	..	..	33	947	46	40	1042	95	638 115	861 455 250
Bug and Indul	27.400	49	05	..	..	1	21	995	46	42	1042	47	23,646	31 922.100
Dneister	30 500	48	32	..	..	2	08	1006	46	20	1049	43	22.029	29 739 150
Maritza	23 700	42	00	..	..	..	22	1129	40	45	1148	19	3,342	4 511,700
Striman	13 000	41	28	..	..	..	30	1138	40	55	1148	10	507	684 450
Vardar	12 300	41	20	..	..	..	10	1141	40	32	1154	13	812	1.096 200
Drin	9 500	42	10	..	25	..	..	1126	41	40	1135	9	302	407 700
Donau	293.100	46	25	..	..	9	50	1047	45	15	1069	22	55.396	74 784 600
Tornea and Kemi district	41 700	67	20	..	..	..	05	585	65	52	621	36	21,111	28 499 850
Wester Botten	36.900	65	50	..	..	2	55	622	64	40	650	28	11.301	15 256.350
Wester Norrland	26.200	63	30	..	..	1	58	678	62	20	705	27	7.460	10 071 000
River Dahl district	20 300	61	16	..	..	2	00	730	60	35	750	20	3,172	4 282 200
Ciara and Gotha Elv	16,700	59	40	1	45	..	..	767	57	48	809	42	11,506	15 533 100
Mälar district	9 400	59	45	..	..	1	10	765	59	25	773	8	235	317.250
Eastern part of South Sweden	5 800	56	55	..	..	1	00	829	56	15	844	15	510	688,500
Western part of South Sweden	6 600	57	30	..	42	..	..	817	56	40	835	18	835	1 127 250
Glommen and Lauven district	21 300	60	52	..	..	..	04	740	59	10	779	39	12,658	17 088.300
Southern part of Norway	9 500	59	18	..	..	..	15	776	58	10	801	25	2,320	3.132.000
Rivers east coast of Adriatic	17 200	43	50	..	20	.	..	1096	43	30	1102	6	241	325.350
Rivers discharging Gulf of Taranto and Ionian Sea	7 500	40	00	..	..	..	25	1164	39	30	1172	8	188	253,800
Western part of South Italy	11 900	41	15	..	30	..	..	1142	40	40	1152	10	467	630.450
Tiber	7,200	42	42	..	17	..	..	1116	41	45	1133	17	814	1,098,900

RIVERS FLOWING TOWARDS THE EQUATOR—*Continued.*

NAME OF RIVER OR DISTRICT.	River Basin.								Mouth of River.				Retardation.	
	Area.	Latitude of centre.		East of outlet.		West of outlet.		Rotary velocity.	Latitude.		Rotary velocity	Incr. of velocity.	By Sediment.	By Water.
	Square miles.	Deg.	M.	Deg.	M.	Deg.	M.	Feet per second.	Deg.	M.	Feet per sec'd.	Feet per sec'd.	Foot-pounds per sec'd.	Foot-pounds per second.
EASTERN HEMISPHERE.														
Arno and west coast of Central Italy	8 900	43	25	..	32	..	..	1103	43	00	1111	8	223	301,050
Etsch district	12 000	46	15	..	..	..	34	1050	45	00	1074	24	2 700	3.645 000
Po	28,100	45	25	.	..	3	10	1065	44	50	1077	12	1 412	1.906,200
Rhone	38.000	45	42	..	41	..	..	1061	43	25	1103	42	26,182	35 345 700
Ter and Slobregat	11,200	42	45	..	..	..	25	1115	42	40	1117	2	18	24 300
Ebro	33 200	42	06	..	..	2	20	1127	41	02	1146	19	4.681	6,319 350
Guadalaviar	8,900	40	10	..	..	..	54	1161	39	20	1175	14	681	919 350
Jucar	8 100	39	15	..	..	1	15	1176	39	00	1180	4	51	68 850
Segura	8 200	38	10	..	..	1	20	1194	38	06	1195	1	3	4 050
Guadalquiver	20.000	37	40	2	02	..	..	1202	36	42	1218	16	2 000	2 700 000
Guadiana	25.700	38	25	2	00	..	..	1190	36	48	1216	26	6,785	9.159 750
Caldoa	7,100	37	48	..	20	..	..	1200	37	40	1202	2	11	14 850
Tagus	28.900	40	00	3	50	..	..	1164	38	50	1183	19	4.075	5,501 250
Duero	38 700	41	30	3	05	..	..	1139	41	15	1142	3	135	182 250
Minho	10 600	42	41	1	15	..	..	1117	42	28	1121	4	66	89 100
Rivers of Great Britain	46 015	..	..	..	..	..	..	..	..	..	..	..	1,181	1.594 350
Rivers of Ireland	16,224	..	..	..	..	..	..	..	..	..	..	..	921	1,243 350
WESTERN HEMISPHERE.														
Bastard, Penticost	33 000	50	50	..	..	..	05	959	49	08	994	35	15,790	21 316.500
Saguenay	27 800	49	02	..	..	2	45	996	48	00	1017	21	4,788	6 463 800
St. John, Penobscot	34.400	46	40	..	..	1	00	1042	45	20	1068	26	9,081	12.259 350
Kennebec, Androscoggin, Saco	13,000	44	45	..	..	..	20	1078	43	55	1094	16	1.300	1.755 000
Merrimack	7 100	43	20	..	..	..	38	1105	42	48	1114	9	225	303.750
Connecticut	10 800	43	20	..	02	..	..	1105	41	10	1143	38	6,091	8.222.850
Hudson, Housatonic	16 000	42	30	..	04	..	..	1120	40	42	1152	32	6 400	8 640 000
Delaware	11 500	41	00	..	03	..	..	1146	39	35	1172	26	3,036	4 098 600
Susquehanna	27 200	41	14	..	..	..	52	1142	39	32	1172	30	9 561	12.907.350
Potomac, Rappahannock	16 000	39	00	..	..	1	15	1180	38	02	1197	17	1,806	2.438 100
James	13 100	37	32	..	..	1	32	1204	36	52	1215	11	619	835 650
Roanoke, Tar	18 800	36	36	..	..	1	40	1220	35	52	1231	11	888	1,198 800
Santee, Neuse	44 100	34	40	..	..	1	25	1249	33	42	1264	15	3,881	5,239,350

Savannah and others	51 200	32	51	..	..	1	05	1276	31	52	1290	14	3.917	5,287,950
Alabama district	128 700	31	30	..	25	..	..	1295	30	15	1312	17	14 543	19 633.050
Mississippi	1,244.000	40	55	..	..	7	10	1148	29	08	1327	179	14,323.668	19,336 951 800
Colorado, Brazos, Trinidad	191,200	31	12	..	..	1	50	1300	28	40	1333	33	81 354	109.827.900
Rio del Norte	215 500	29	50	..	..	6	40	1318	25	30	1371	53	236 457	319,216,950
Colorado	267.000	36	04	1	06	..	..	1228	32	15	1285	57	338 890	457,501,500
Rivers east coast of Gulf of California	140 000	28	06	1	10	..	..	1340	27	00	1353	13	9 240	12.474 000
Kalamath and Tsashtl	42 900	42	00	1	15	..	..	1129	41	45	1133	4	268	361 800
Columbia	283.400	45	52	7	02	..	..	1058	45	48	1059	1	111	149 850
Frazer	138 300	51	28	..	..	..	40	946	49	02	996	50	135 050	182 317,500
Simpson and Frances district	53 600	56	40	2	00	..	..	835	55	10	871	36	27.135	36.632 250
Atna or Copper	34 900	62	12	..	05	..	..	708	60	20	752	44	26 393	35 630 550
Bolsas, Yopez, Verde	71 500	18	00	..	05	..	..	1445	16	42	1455	10	2 788	3.763 800
Sirano district	24 700	14	00	..	10	..	..	1474	13	30	1477	3	86	116 100
San Juan de Nicaragua	23 700	12	00	..	..	1	20	1486	11	15	1490	4	148	199 800
Sacramento	33 000	40	00	..	..		08	1164	37	50	1200	36	16,706	22,553.100
Parahyba and Grande	37.600	6	40	..	..	1	50	1509	5	40	1512	3	132	178 200
Ciara, Croayhu	33 700	5	08	..	..	..	05	1513	3	10	1517	4	211	284 850
Jaguaribe	19.900	5	50	..	..	..	30	1511	4	30	1514	3	70	94.500
Belmonte and Doce District	114 400	17	25	..	..	1	48	1449	17	00	1453	4	715	965 250
Parahyba (South)	35 800	22	00	..	..	2	12	1408	21	30	1413	5	349	417.150
St. Francisco	247.600	14	00	..	..	7	00	1475	10	20	1494	19	34 912	47.131,200
Paranahyba	157.300	8	05	..	..	2	30	1504	2	58	1517	13	10.382	14 015.700
Maranhao and Itaqieura	59 600	5	00	..	..	..	40	1513	2	50	1517	4	373	503.520
Gurupy and Turyassu	49 000	3	20	..	..	1	00	1516	1	00	1519	3	172	232.200
Tocantins	376 000	10	10	..	..	1	00	1495	2	00	1518	23	77 738	104.946.200
Amazon	2,236,000	6	20	..	..	12	50	1510	1	25	1519	9	70 993	95,840,550

BALANCED SLIDE VALVES.—At the meeting of the Institute of Mechanical Engineers held at Birmingham yesterday week, a paper was read entitled "Description of a Balanced Slide Valve for Locomotive Engines," by Mr. William G. Beattie, of London. This slide valve is similar in shape to the old D valve, being made cylindrical at the back, and working inside a jacket of corresponding form fixed in the steam-chest; the steam pressure is exclued from the back of the valve by two steam-tight packing rings, one at each end of the valve, which are fitted into grooves in the body of the valve, and are pressed outwards against the jacket by means of spiral springs. The valve is thus relieved of the heavy pressure of steam, which in ordinary unbalanced slide valves forces the valve against the cylinder face with a pressure that amounts in large engines to as much as 9 or 10 tons on each valve. The result has been found by experiment to be that the balanced slide valves, which are made of cast iron, require only about one-third of the power to move them that is necessary with the ordinary unbalanced valves made of brass; the excessive wear and tear to which the ordinary valves and the link motion working them are subjected, is thus avoided with the balanced valves, and there is considerable saving both in first cost and maintenance; there is also an important advantage in the facility with which the engine can be reversed with steam on. The economy of fuel consequent upon the saving in the power required to work the balanced valves has been found by the experience of continued working to amount to 2½ lbs. of coal per mile run; and a large number of engines, both passenger and goods, have been fitted with these valves.

THE MECHANICS OF FLYING.

By LUDWIG KARGL.

Translated from "Der Civil Ingenieur."

The object of this investigation is to determine under what circumstances it is possible for a machine to raise itself in the atmosphere, and at the same time guide its motion in any given direction.

We learn from history that in ancient times attempts were made to imitate the flight of birds, and that the experiments all failed from defect of construction or lack of muscular strength. In modern times elevation into the atmosphere became possible by means of the balloon; but the problem of controlling direction remains unsolved. Sails and rudders do not work, because the aerial ship is entirely surrounded by air; and progression by sail, screw, rudder, or any other mechanism is not to be attained, because the balloon has so great a magnitude in proportion to its force of inertia, that the motors which it can carry with it are not sufficient to oppose the resistance of a strong counter breeze.

Of late, attempts have been made, especially in England, to follow the path pointed out by nature; that is, that of raising a machine without the aid of a balloon by means of wings driven by steam.

That no result has been so far obtained is explained by the fact that the mechanical work required for flying is very great; so that the weight of a very light flying machine is much too great compared with the work performed by it.

It is therefore surprising that Prechtl in his work, "Untersuchungen uber den Flug der Vögel; Wien, 1846," states that the mechanical work done by birds during flight is quite small, and that their muscular power does not greatly exceed that of other animals. The error underlying this statement will be shown in the course of this article. As the assumptions leading to this result were found to be unwarranted, the writer was compelled to proceed from entirely different data.

The object of this paper is at present confined to the determination, upon the basis of an investigation of the motions of flight, of the work per second necessary to maintain a flying-machine of given weight in the atmosphere, by means of wing-strokes. We shall thus find the weight per horse power that must not be increased, if the machine is to float in the atmosphere.

My thanks are due to Dr. Gustav Zeuner for his aid and share in this labor.

1.—RESISTANCE OF SURFACES IN MOTION IN AIR AT REST.

We first give the necessary theory concerning the resistance of the wing-surfaces.

Known deductions and experiments show that for plane or slightly curved surfaces the resistance (W) is proportional to the projection of the surface, normal to the direction of motion (F), and also to the square of the velocity (v), as well as to a constant c, determined by experiment, giving

$$W = c \cdot \frac{F v^2 \gamma}{2g};$$

γ being the density of the atmosphere; that is, the weight of a cubic metre of air at standard thermometer and barometer, and g being the acceleration due to gravity = 9.81 metres.

In considering the motions of wings, we have to do, not with rectilinear but with angular motion.

The resistance of a surface element at the distance x from the axis of rotation is

$$d W = k a^2 x^2 y \, dx,$$

k being $= c \cdot \frac{\gamma}{2g}$, and a being the angular velocity.

The total resistance of the surface is

$$W = k a^2 \int y x^2 \, dx = k F a^2 \frac{\int y x^2 \, dx}{\int y \, dx} = k F a^2 n^2$$

The resistance of the rotating surface is therefore equal to the resistance of the same surface moving in a straight line with the velocity of a point at the distance n from the axis. This point will be called the point of resistance. This lies at the distance

$$n = \sqrt{\frac{\int y x^2 \, dx}{\int y \, dx}}$$

Special Cases.—1. Let the surface be a rectangle $a \times b$, revolving about the side b; then

$$n_r = \frac{a}{\sqrt{3}} = 0,577\, a.$$

2. Let the surface be a parabola. This may be taken as an approximation to the wing form. The equation is

$$y^2 = p\, x^1.$$

As Y is the axis of rotation

$$y^2 = p\,(l-x).$$

For

$$y = g,\ x = 0,$$

and

$$y^2 = \frac{g^2}{l}\,(l-x),$$

giving

$$n_p = l\,\sqrt{\frac{8}{35}} = 0,479\, l.$$

2.—MOMENT AND POINT OF APPLICATION OF THE RESISTANCE.

The moment of the restance is

$$W_m = a^3\, k \int y x^3\, dx$$

and the distance of the point of application from the rotation-axis is

$$m = \frac{\int y x^3\, dx}{\int y x^2\, dx}$$

Special Cases.—1. For the rectangle $a \times b$, about the side b,

$$m_r = \frac{3}{4}\, a.$$

2. For the parabola with axis perpendicular to the rotation-axis, and distant l from it,

$$m_p = \frac{2}{3}\, l.$$

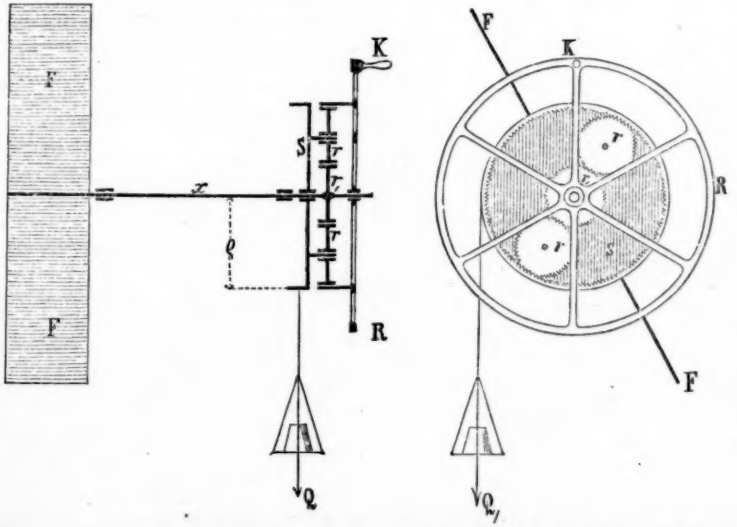
In Prechtl's work this distinction between the point of resistance and the point of application of the resistance is not made. Still, this error has no important influence upon the final result.

3.—EXPERIMENTS TO DETERMINE THE COEFFICIENTS OF RESISTANCE.

If a surface revolves in air at rest, the parts at a greater distance from the axis have a greater velocity than those nearer, hence the rarefaction increases outward from the axis, and, as a consequence, there is a flow of air radially outwards. Hence a greater quantity of air is set in motion than in the case of rectilinear motion, and the coefficient c must therefore be larger.

In my experiments I employed the dynamometer represented in Fig. 1. Upon its axis χ a double wing F was fastened,

FIG. 1.



so that resistance of the air formed a couple that did not increase the pressure upon the axis. The disk S, of radius ρ, runs loose on the axis, and carries driving

teeth for the intermediate wheel r. These act upon the wheel r_1, which is locked to the axis, being moved by the large wheel R. If the crank K is turned just so fast that the scale containing the weight Q_1 remains stationary, then the resistance at the surface of the disc S is equal to Q_1. Therefore if the wheels r are equal to the driver r_1, the resistance of the atmosphere upon the whole surface *plus* the resistance due to friction must be

$$W_1 = \frac{Q_1 \rho}{3m};$$

The pair of wings consisted of a light wooden frame 1.5 m. long by 0.3 m. broad, covered with cartoon paper. In order to eliminate the friction and resistance of the wooden frame the paper was removed and the frame revolved. This resistance is

$$W_2 = \frac{Q_2 \rho}{3m};$$

hence the resistance of the air

$$W = W_1 - W_2 = \frac{\rho}{3m}(Q_1 - Q_2)$$

The radius of the disk S is $\rho = 0{,}1675$ met. ; barometer at 720 millim ; temperature 20° Cels. ; hence, the density $\gamma = 1{,}141$ kilog.

Let u = number of revolutions per minute ; the results are then as follows :

Q_1 =	2	2.5	3	3.5	4	4.5	5	5.5	kil.
u =	21	23.5	26	28	30	32	34	36	
Q_1 =	6	6.5	7	7.5	8	8.5	9	9.5	10
u =	37.5	39	40	41	42	43	44	45	46
Q_2 =	0.5		1	1.5	2				
u =	20		31	41.5	51				

Constructing a curve having for abscissas the number of revolutions per minute, and for ordinates the corresponding values of Q_1 Q_2, it is obvious from its form that the resistance of the atmosphere increases somewhat more rapidly than the square of the velocity. We find for

u ..... =	20	25	30	35	40	45
v the velocity in terms of radius of resistance .. =	0.91	1.13	1.36	1.58	1.82	2.04
C ..... =	6.3	6.1	6.3	6.5	6.5	7.3

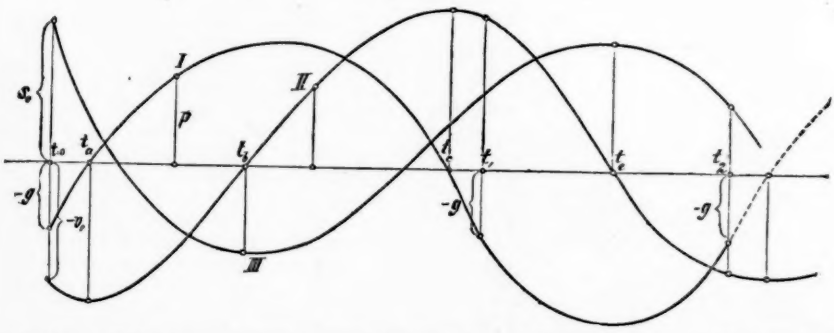
These values may seem somewhat large, but the experiments, though not exact, are sufficiently so for the end in view, and the deduced number of wing-strokes of birds corresponding to these coefficients agrees closely with the results of observation.

4.—INVESTIGATION OF THE MOTIONS OF FLYING.

When the law of motion of wings is known, and the wing-surface is given, the resistance W at any time can be determined.

The vertical component of this resistance (the buoyant effort) and the total weight G act at the centre of gravity. If upward direction is positive, then during the down-stroke the buoyant effort *minus* the weight acts in the direction of motion, *i. e.*, $K = A - G$. During the back-stroke the buoyancy is negative; hence the last equation represents the force acting at the centre of gravity if the proper sign is given to A. Hence the centre of gravity moves with an acceleration $p = \frac{K\,g}{G}$

FIG. 2.



Setting off the time as abscissa, and the acceleration as ordinate, we obtain a curve (I) Fig. 2, which can be determined when the law of flight is known. The surface bounded by this curve, taken between 2 ordinates, gives

$$\int p\,dt = v_1 - v_0;$$

that is the increase of velocity of the the centre of gravity during the time represented by the intercept between the ordinates.

If the initial velocity (when $t = o$) is given, the velocity at any time can be found. This gives a second curve (II). The surface limited by this curve, taken between 2 ordinates, is

$$\int v\,dt = s_1 - s_2,$$

and hence it represents the increase of the path of the centre of gravity during the time represented by the intercept between the ordinates.

If the initial space (for $t = o$) is given, the position of the centre of gravity at any moment can be found; giving the curve III.

If the wing begins a down-stroke at $t = o$, then $p = g$. The acceleration for $t = t_0$ is o; hence the negative velocity is a maximum at this point. At t_3 the velocity is o; hence at this point the positive velocity is a maximum. At $t = t_1$ the down-stroke ends and the return-stroke begins. At t_0 the velocity is o; hence the stroke is a maximum. At t_2 the back-stroke ends, and the period begins again. These 3 curves, therefore, completely represent the circumstances of motion of the centre of gravity, giving the position and velocity at any moment.

The motion of the wings should be so adjusted that the velocity at the end of each down-stroke shall be zero; otherwise a certain amount of work would remain stored up in the wing, thus remaining ineffective.

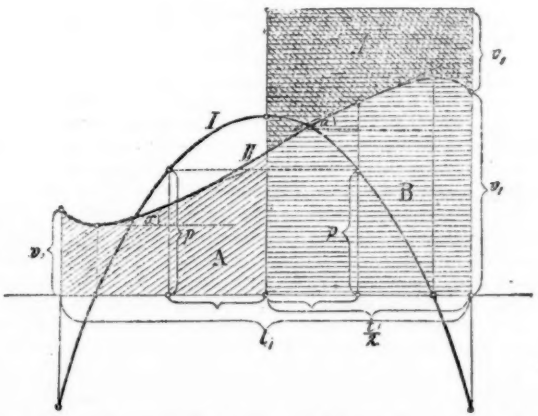
Prechtl assumes that the motion of the wing is uniformly accelerated, so that the final velocity is also the maximum velocity, which, according to the above analysis, would not be an economical disposition.

Without assuming a fixed law of motion I will suppose that the motion of the wings is symmetrical in relation to their (horizontal) middle position. Then the buoyant action and the force K acting at the centre of gravity is equal in magnitude and direction for two positions of the wings at equal distances above and below their mean position. And the time required to pass from a given position to the mean place is equal to the time required to pass from the mean position to a position at equal distance below.

It follows that the curve I, which represents the relation between time and acceleration, is symmetrical with reference to the mean position.

Concerning the course of the curve II, which gives the relation between velocity and time, we find that the angle of the tangent with the axis of abscissas at a point on this curve is $p = \frac{dv}{dt}$; hence it is equal for two positions, equally distant above and below the mean plane (Fig. 3.)

FIG. 3.



It follows that the obliquely hatched surface A must be equal to the obliquely hatched surface A_1. The entire surface bounded by the curve II and the axis of

abscissas represents the space described by the centre of gravity during the back-stroke (in the time t_1.) This surface then is equal to the rectangle B, and

$$s_1 = \frac{t_1}{2_1}(v_1 + v_0)$$

This formula derived for equally accelerated motion, also holds for any kind of motion, provided that the accelerating force after a certain time decreases according to the same law by which it has increased; and the law holds for points equally distant from the mean position.

During the back-stroke, the space described by the centre of gravity is

$$s_2 = \frac{t_2}{2}\cdot(v_1 - v_2)$$

and the path for an entire period is

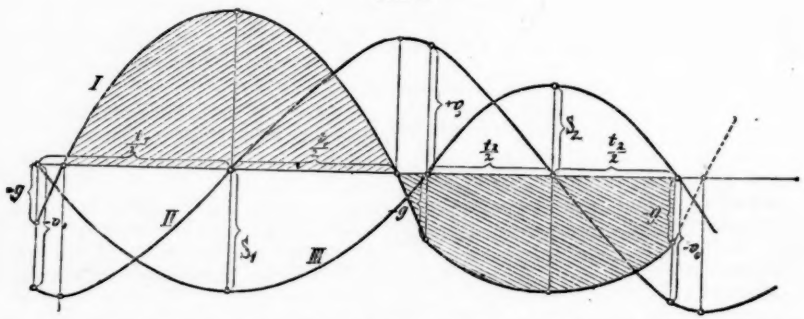
$$S = s_1 + s_2 = \frac{t_1}{2}(v_1 + v_0) + \frac{t_2}{2}(v_1 + v_2).$$

Therefore, in order that there may be rising on the wings, the velocity of the centre of gravity at the end of the down-stroke must be equal, and opposed in direction to the velocity at the end of the back-stroke.

Again, the centre of gravity at the ends of both strokes must lie in the original positions (Fig. 4.)

At the time $t = o$ (beginning of the down-stroke) the velocity is $-v$. At the moment when the buoyant force is equal to the weight of the apparatus, this velocity is a negative maximum. From this point it diminishes, until it becomes 0, when $t = t^1$ (mean position, wings horizontal). At this time the space is a negative maximum $= S_1$. The velocity is now positive, the negative path is less, until $t = t^1$, when the velocity $= +v$ and the space $= 0$. The back-stroke

FIG. 4.



now begins. The centre of gravity is at the initial position, but has a positive velocity v, and consequently the path is positive. The velocity diminishes, until at the middle position it becomes 0, and the space in the positive direction is a maximum $= S_2$. Now the velocity is negative, the space diminishes, and at the end of the back-stroke (after a complete period) the initial circumstances recur. The centre of gravity is at the initial position and has the velocity v. These results hold for any motion which is symmetrical with reference to the mean position.

As the surface included between the curve II and the axis of abscissas is equal to the increment of the path of the centre of gravity in the interval of time represented by the distance between the ordinates, and as this increment for an entire period is equal to zero, this surface for the interval t_1 to t_2 must be taken equal to zero; consequently the portion above the axis of abscissas must be equal to the portion below.

And as the surface included between the curve I and the two ordinates is equal to the increase of the velocity of the centre of gravity in the interval represented, and as this increase for an entire period is zero, this surface for the interval from t_1 to t_2 must be taken equal to zero, and the hatched portion above the axis of abscissas must be equal to the hatched portion below.

This gives a very convenient means of determining directly the equation of condition for rising. It may be expressed as follows:

Set off the times as abscissal; the accelerating force (buoyancy *minus* weight),

acting at the centre of gravity, as ordinates; then for an entire period the corresponding surface must be divided into two equal parts by the axis of abscissas.

5.—OF THE LAWS OF MOTION OF THE WING SURFACES.

For the construction of an artificial flying apparatus, motion by means of crank motion is recommended, because this is the simplest mechanism corresponding to the condition, that the velocity at the end of each stroke shall be zero. The law of crank motion does not give exactly the motion of the wing surfaces relative to air at rest: first, because the centre of gravity is in motion; and again, because, in consequence of the motion of the wings, which have a certain weight, the main body of the apparatus has a motion relative to the common centre of gravity. This motion is analogous to the oscillating motion of locomotives, and is due to the laws of the motion of the centre of gravity. But these motions have no important influence upon the buoyancy generated by the wing surfaces, because —

(1.) As regards the velocity of the centre of gravity of the entire apparatus, it is always small compared with the velocity of the wings. This influence is still less, because it is greatest near the beginning and end of the strokes, and therefore at points where (except for large stroke-angles) the wing surfaces have first departed a little from the vertical position; hence the vertical velocity of the centre of gravity cannot have much influence upon the resistance of the wings. If the wing is horizontal (at mean position), the velocity is zero in any event, and for small angles it generally disappears entirely.

(2.) As regards the motions of the wing frame, these are so slight that the ratio of the weight of wings to that of the body is insignificant.

[TO BE CONTINUED.]

BRONZE FIELD GUNS.

From "Engineering."

When argument and common-sense reasoning fail to convince of error, practical results generally step in and right matters, except, perhaps, where obtuseness is only rendered more obtuse by the absoluteness of the failure. There are some people who will never change their ideas, although their pet schemes lie exploded before their very eyes. Whether Col. Maxwell will accept as a decided defeat the recent failure of the bronze guns at Shoeburyness we know not. For the sake of the army, however, and of the nation dependent upon it, if not for his own sake, we recommend him to do so. The results of the recent trials have been kept as quiet as possible; but notwithstanding this, it is now well known that the three bronze 9-pounder guns taken for testing as samples from the batch recently cast at Woolwich, have proved signal failures. This is not to be wondered at when we reflect that they are the embodiment of Col. Maxwell's opinions upon the subject, and of which he is so proud as being the reflex of opinions held four and a half centuries since. Fortified by such a fortuitous circumstance as this must be, we may presume that Col. Maxwell will still adhere to this opinion, its very antiquity being in his eyes sufficient proof of its correctness. The three guns in question were made at the Royal Gun Factory, Woolwich, and we may be quite certain that nothing was left undone that could be done in order to render them a success, except only that one element was omitted—common sense. These guns all failed after about 200 rounds had been fired from each of them, large holes and deep fissures being developed in the bores. To what cause this may be owing we do not now stay to inquire, not having examined the guns. Probably the metal, which is that of some of our old bronze guns, suffered in remelting, the tin, which has to be added at each remelting, not properly amalgamating with the body of the metal, but collecting in small pockets. These would form soft spots on which the action of firing would soon tell. That this is the case indeed seems clear, for it is not ordinary erosion that has occurred,

and this probability is strengthened by the wide difference between the melting temperatures of copper and tin.

Guns of this metal, when made sufficiently hard to withstand friction and erosion, are too brittle to resist the shock of the explosion of the charge. On the other hand, if the metal be of a sufficient degree of toughness, so as not to break, it will be too soft to withstand the action of the powder when fired. When smooth bores and round shot were the fashion, the percentage of defective castings in bronze guns was very high, whilst with rifled ordnance that percentage has greatly increased. With new metal these results are bad, but when old guns are remelted it is infinitely worse, for the reasons we have given. So difficult is this metal to manage, and so thoroughly unreliable is it in itself, that of two guns cast from the same run of metal, one may turn out well whilst the other will be a positive waster. The difficulties which attend the successful manufacture of bronze guns were well understood at Woolwich, and attempts were made to overcome them, with what success let the three miserable examples at Shoeburyness tell. The first and experimental guns proved more successful, but those sampled from a working batch have told a different tale. The truth is that the appearance of these fissures, from what cause soever they may proceed, only anticipates the failure which would inevitably have resulted soon after twice 200 rounds had been fired from each of them. The French bronze guns are usually recast after about 500 rounds, and we see no reason why English guns made of a similar compound should stand any better. There is no doubt that a trial of one of these guns, if pushed a little beyond the above figures, would develop what Col. Maxwell terms "ample indication of approaching rupture;" that is, the gun would burst and a good-sized piece would be "thrown out of the chase with violence." This we are inclined to consider a decided rupture of itself, and not a mere indication of that event as Col. Maxwell does. It is fortunate for the interests of the public that these results have followed, as well as for the progress of the science of gunnery, which, however, could not have been much retarded by the perpetration of such a blunder. But the bane and the antidote lie very close together, and we commend this failure to the special notice of all those who have not sufficient intelligence to enable them to discriminate between the relative merits of bronze and steel for field guns.

International Pacific Railway.—An International Pacific Railway Company proposes to apply to the Parliament of the Dominion of Canada in its next session for an Act of Incorporation. The proposed line would branch from the Grand Trunk of Canada, and run to Sault Ste. Marie, where it would cross the river, and pass through American territory, coming into Canadian soil again at Pembina. From Pembina it would run *via* Fort Garry to the Pacific.

Brazilian Enterprise.—A concession has been granted to some Brazilian gentlemen for working the Taubate coal beds in Sao Paulo. The President of Maranhao is promoting the formation of a company with a capital of £40,000, to take up and deepen the abandoned canal of Araparahy, which will connect two important river navigations. His Excellency proposes to assist the undertaking with a provincial guarantee of interest.

New Zealand Railways.—Surveys for lines in the province of Auckland, New Zealand, have been rapidly proceeded with of late. In going over old surveys, it has been found necessary to lay down a new line in most places, as in consequence of luxuriance of undergrowth and the rapid decay of timber used as marks, all vestiges of a line laid out some time since had become obliterated.

Richelieu, Drummond, and Arthabaska Railway.—The Company which is carrying on this Canadian line, has ordered 2 locomotives and 50 platform cars to be delivered on the line of the road by May 1. The locomotives are to be of the same make as one in use on the Quebec and Gosport Railway. The new line will run from Sorel to Acton, on the Grand Trunk Railway of Canada.

THE STEAM INJECTOR.

By A. WINKLER.

Translated from "Zeitschrift des Vereines Deutscher Ingenieure."

According to the mechanical theory of heat, mechanical work and heat are equivalent. To each unit of heat corresponds a work of 424 metre kilograms, the heat-unit being the amount required to raise a kilogram of water 1° Centigrade. To produce a work of one horse-power or 75 metre-kilograms, $\frac{75}{424}$ heat-units per second are necessary, or 636.8 heat-units per hour; whatever the nature of the working body and whatever the law of cooling.

Steam is generally employed in the conversion of heat; the process being briefly as follows: steam is generated under constant pressure, it is then allowed to expand in the cylinder without further application of heat, then to pass off freely, or into the condenser, from which it passes again as water into the boiler.

To produce a kilogram of a mixture of water and steam under constant pressure, if the feed-water has a temperature of 0° the following conditions are necessary:

(1). The water must be raised from the zero point to the temperature, t_1 of the steam, for which a quantity of heat $q_1 = \int_0^{t_1} c\,dt$ is required, c being the specific heat under constant pressure.

(2.) If each kilogram of the mixture contains m_1 kilograms of steam and $1 - m_1$ kilograms of water, then an internal latent heat $m_1 \rho_1$ is required to generate m_1 kilograms of steam.

(3.) The constancy of pressure requires a continuous discharge of steam, corresponding to the work $p_1 m_1 (v_1 - \sigma)$, or to a quantity of heat A p_1 m$_1$ $(v_1 - \sigma)$; in which $A = \frac{1}{424}$, the equivalent of heat for a unit of work; p_1 = the absolute steam-tension (expressed in kilograms) to the square metre; V_1 = the volume of 1 kilog. of steam; σ = the volume of 1 kilog. of water; hence $m_1 (v_1 - \sigma)$ = the increase of volume of 1 kilog. of mixture.

(4.) Continuous supply is also necessary, corresponding to a work = $p_1 \sigma$, or to an amount of heat = A $p_1 \sigma$.

Hence the amount of heat needed to generate a kilogram of mixture is

$$Q_1 = q_1 + m_1 \rho_1 + m_1 A p_1 (v_1 - \sigma) + A p_1 \sigma \quad (1.)$$

Employing the sub-index 2 for the corresponding quantities at the final condition of the steam, we find the quantity of heat that must be withdrawn from the expanded steam to convert it into water of the temperature 0° is

$$Q_2 = q_2 + m_2 \rho_2 + m_2 A p_2 (v_2 - \sigma) + A p_2 \sigma \quad (2.)$$

The quantities in equations (1) and (2) can be taken from tables, with the exception of m_1 and m_2. If m_1 is determined, m_2 is found by means of the equation of the adiabatic curve, *i. e.*, the curve of variation without reception or emission of heat:

$$\frac{m_2 r_2}{T_2} + r_2 = \frac{m_1 r_1}{T_1} + r_1 \quad (3.)$$

in which

$$r = \int_0^t \frac{c\,dt}{T} \text{ and } r = \rho + A p (v - \sigma)$$

and T, the absolute temperature = $(273° + t°)$ C.

As the work in the cylinder was without reception or emission of heat, the quantity of heat converted into work is simply expressed as follows,

$$A L = Q_1 - Q_2 = q_1 - q_2 + m_1 r_1 - m_2 r_2 + A \sigma (p_1 - p_2) \quad (4.)$$

Consequently the ratio of consumed to received quantity of heat is

$$\eta = \frac{Q_1 - Q_2}{Q_1} = 1 - \frac{Q_2}{Q_1} = \frac{A L}{Y_1} \quad (5.)$$

The consumption of steam expressed in horse-power for an hour, is found from the equation $G \cdot A L = 636.8$; from which

$$G = \frac{636.8}{A L} = \frac{636.8}{Q_1 - Q_2} \quad (6.)$$

And the fuel consumption per horse-power for an hour is

$$W = G.Q_1 = \frac{636.8}{\eta} \text{ units of heat.} \quad (7.)$$

The following table is calculated from these formulæ:

p_1	p_2	m_1	m_2	Q_1	Q_2	AL	η	G	W
5 atmospheres	1 atmosphere	1.00	0.909	653.049	588 202	64 847	0.0993	9.82	6412.6
		0.80	0 746	553 212	500 592	52 620	0 0951	12 10	6696 1
	0.5 "	1.00	0 877	653 049	563.856	89 193	0.1366	7 14	4661.8
		0.80	0.725	553.212	480 347	72 865	0 1317	8 74	4835 2
10 atmospheres	1 atmosphere	1.00	0.873	661.738	568.888	92.850	0.1403	6.86	4538.8
		0.80	0 726	565 983	490.023	75 960	0.1342	8 39	4745.2
	0.5 "	1 00	0.843	661 738	545 176	116 562	0.1761	5 46	3616.1
		0 80	0.707	565.983	470.458	95.525	0.1688	6 67	3772.5

The values of G and W are much smaller than those generally taken in practice, because of the neglect of hurtful resistances of all kinds. The values of η show that the steam engine is a very wasteful machine, since 0.85 @ 0.9 of the applied quantity of heat is lost. In the determination of the values of Q_1 conditions are assumed which are not fulfilled in practice; for example, a boiler is never fed with water at 0°; and in finding the work $p_1 \sigma$ of the feed pump, the absolute pressure p_1 is made use of, though this is greater than the suction-height. The quantity of heat employed in feeding is very small and without influence upon the value of η, but previous warming of the water may serve to economize considerably; for the quantity of heat q_0 contained in the water is to be taken from Q_1, while the difference $Q_1 - Q_2$ remains the same; the heat Q_2 in the emitted steam is also diminished just as much, provided that the warming of the water is effected by means of the emitted steam or by previous heating. To pass to the other extreme, suppose the feed water heated to 80°, corresponding to a quantity of heat q_2=80,282, we shall find the values of η as stated in the following table:

Water at 0	$\eta = 0.0993$	0.0951	0.1366	0.1317	0.1403	0.1342	0.1761	0.1688
" 80	$\eta = 0.1132$	0.1113	0.1557	0.1541	0.1596	0 1564	0.2005	0.1967

Notwithstanding the high temperature the value of η is still quite small, and in ordinary practice the only use of it is that $Q_1 - Q_2$ is made as large as possible; that is, great steam tensions are employed and worked with great expansion. Yet there is another application not yet realized in practice; this consists in pumping the steam into the boiler instead of condensing it. The cyclic process of the steam engine is by this means simplified in a great degree, and the only question remaining is, whether the work so gained leads to better or worse use of the admitted quantity of heat.

Of the many means employed to restore the steam from the cylinder, without condensation, to its original condition, the simplest and most available is the injector.

Let G, as before, indicate the quantity of steam consumed in an hour per horse-power, which must be returned to the boiler; G_0= the quantity of steam required by the injector in the same time; we then have the amount of heat contained in G_0 (if the water held in G_0 and in G is the same):

$$G_0 Q_1 = G_0 (q_1 + m_1 r_1 + A p_1 \sigma)$$

and the quantity of heat contained in the steam taken up is

$$G Q_2 = G (q_2 + m_2 r_2 + A p_2 \sigma).$$

After the admission of $G_0 + G$ kilog. of mixture into the boiler the quantity of heat contained is

$$(G_0 + G) Q_0 = (G_0 + G) q_1 + m_3 r_1 + A p_1 \sigma)$$

and as heat has neither been added nor withdrawn during the proeess, the quantities before and after mixture must be equal, *i. e.*:

$$(G_0 + G)(q_1 + m_3 r_1 + A p_1 \sigma) = G_0 (q_1 + m_1 r_1 + A p_1 \sigma) + G(q_2 + m_2 r_2 + A p_2 \sigma).$$

This formula leads to the equation for the water injector given by Prof. Zeuner, if m_3 and $m_2 = 0$, and for $p_2 \sigma$ the suction height h is substituted; and also, instead of q_1, the quantity of heat q', due to the introduction of the mixture into the boiler, from equation (8)

$$G_0 = G \left(\frac{AL}{r_1 (m_1 - m_3)} - 1 \right)$$

$$G_0 = 636.8 \left(\frac{1}{r_1 (m_1 - m_3)} - \frac{1}{AL} \right) \quad (9.)$$

in which G_0 is expressed in kilograms for horse-power per hour.

There are consequently $G_0 + G$ kilog. of water and steam at boiler temperature, but containing less steam; to bring this mixture to the original working condition the quantity of water $(G_0 + G)\ (m_1 - m_3)$ must be converted into steam, requiring a quantity of heat

$$W = (G_0 + G)(m_1 - m_3)\, r = G.AL \qquad (10.)$$

and this is the same quantity of heat which is converted into work by the machine; hence, in consequence of this process, the steam engine would be not only a very economical but a perfect and exact motor, since η reaches its highest value, *i. e.*, 1; no reference being had to hurtful resistances.

Equation (9) leads to the following conclusions:

(1.) The value m_3 must always be less than m_1; hence, during the whole process there is neither formation of steam nor superheating.

(2.) The value of r_1 makes the quantity of steam G_0 depend upon the steam-pressure in the boiler; and the amount of steam required seems to increase slowly with increasing pressure.

(3.) The steam required in suction has a peculiar relation to the condition of the steam used, in consequence of the value A L. If A L, that is, the work of each kilogram of steam is large, and therefore of high expansive power, with great difference in initial and final conditions, then G_0 must be large, or larger than in case of weak expansion and high final value. In machines of variable expansion, therefore, the quantity of steam G_0 in the injector should be subject to regulation; if the apparatus, in consequence of the indetermination of m_3, is not automatic; for the formula (9) indicates only the limits of m_3 that should not be passed; and of these limits

$$\left(m_3 = m_1 \text{ and } m_3 = m_1 - \frac{AL}{r_1}\right)$$

the first gives $G_0 = \infty$; the other, $G_0 = 0$. In general, to every value of G_0 or m_3 corresponds a determinate curve of variation, and the object is to determine those values which reduce the dimensions of the apparatus to a minimum, and at the same time afford the greatest scope of application.

To reduce the dimensions to a minimum, it is better not to pass with m_3 beyond m_2; as a part of the heat contained in G_0 would be expended in the generation of steam, which is not the object of the apparatus. To obtain a better suction the value of m_3 should be a little less than that of m_2; in consequence of which the steam G is a little more condensed, and the heat set free, or the work can aid the action of the injector. The limits of m_3 are

$$(\text{max.})\ m_3 = m_2;$$
$$(\text{min.})\ m_3 = m_1 - \frac{AL}{r_1} \qquad (11)$$

As m_1 and m_2 in practice are not exactly fixed, there is always an uncertainty in the determination of the value G_0, which can be obviated only by practice.

(4.) In formula (9) m_1 may be greater or less than unity; that is, the steam may be saturated or superheated. In the latter case it is conceivable that the superheating may be carried so far that the whole amount of heat G.A L is communicated to the steam entering the injector, and the boiler would need no more heating. For it, might be substituted a simple steam reservoir, with or without water space depending on the value of m_3, whether greater or less than unity. In the latter case the steam-engine would be converted into a permanent gas-engine. Either case represents a simpler and cheaper project than the ordinary engine. It is to be wished that those conjectural improvements may somehow be realized in practice, so that 80 per cent. of the fuel used in heating the steam engine may not be lost to its effective work.

AMERICAN RAILS.—The first American rail was rolled some 30 years since. Last year more than 600,000 tons were made, more than half in Pennsylvania, the rest in New York, Troy, Rome, Syracuse, Elmira, and Buffalo.

BRAZILIAN RIVERS.—Surveys of the rivers Macao and Mossoro, in the province of Rio Grande del Norte, are about to be made with the view of forming plans and estimates for improving the navigation and marking off their respective channels.

THE Sutro Tunnel is in 1,800 ft., and has struck a large body of water.

STEEL TYRES.

From "Engineering."

The recent disastrous accident at Hatfield, on the Great Northern Railway, resulting from the breakage of a steel tyre, and the fact that a number of such tyres have broken on different lines during the inclement weather of the last fortnight or so, although fortunately without giving rise to fatal results, renders it desirable that the attention of railway managers should be directed to a point of danger connected with the use of such tyres, which does not always receive the consideration it deserves. The point to which we refer is the excessive hardness too frequently given to the steel of which tyres are made. The first steel tyres largely used in this country were those manufactured by Krupp, and they were tyres made of a far softer kind of steel than is commonly used for such purposes. Experience, in fact, showed that a harder kind of steel could be used with safety, and Krupp himself has considerably increased the hardness of his tyres since their first introduction. As the tyres of other makers came largely into the market there arose a strong competition, which has its effect not merely on the price on the tyres, but on the nature of the material of which they were made, the endeavors of the rival manufacturers to obtain a high "mileage" from their tyres leading them to employ, in many instances, steel of a far harder kind than is advisable on the score of safety.

Railway superintendents are, we fear, frequently apt to attach somewhat too much importance to the power of a tyre to resist wear, and too little to the dynamic strength of the material of which it is made; but we trust that the recent accidents may lead to an improvement in this respect. We have seen steel tyres bent cold, so that the opposite sides of the hoop met, and this without showing any sign whatever of fracture; but we believe that but a small proportion of the tyres now made, and most highly commended for their wearing qualities, would stand anything like such a test satisfactorily. It should be endeavored to obtain durability for a tyre by closeness and uniformity of texture, and not by excessive hardness, and it is especially advisable that railway engineers should take more effectual means to ascertain the precise character of the material they employ than is now very generally the case.

Another point also to which it is desirable we should direct attention is the excessive amount of shrinkage, but too frequently given to steel tyres. The shrinkage which it is desirable should be given to a tyre ought to be determined by two things—namely, the elasticity of the material of which the tyre is composed, and the rigidity of the wheel upon which it is placed. The greater the elasticity of the tyre, and the less the rigidity of the wheel, the greater the amount of shrinkage which may be safely given. When a tyre is in use, a strain is put upon it by the action of centrifugal force, and in the case of a wheel running at express speed, or, say, about 50 miles per hour, this strain amounts to about 4 tons per square inch of section, it being supposed that the whole strain is resisted by the tyre itself, and not by the fastenings. In shrinking on a tyre, the initial strain put on should be slightly in excess of that produced by centrifugal force at the highest speed at which the wheel is to be run, so that the only effect of the centrifugal force may be to diminish the grip of the tyre on the wheel, but never to cause the tyre to become loose on the latter, or to put a radial strain on the fastenings so long as the tyre remains unfractured. The amount of excess of the initial tension above that due to centrifugal force, which it is desirable to give to a tyre, will depend upon the material of the latter and its tendency to become stretched in use. With steel tyres of moderate hardness, the amount of this excess need be very small.

We have said that the amount of shrinkage given to a tyre should depend upon its hardness and the rigidity of the wheel upon which it is placed; and it is in estimating this latter quantity that the main difficulty in determining the proper shrinkage exists. A steel tyre of moderate hardness and average good quality will, if put upon a perfectly rigid wheel, have an initial strain of about $3\frac{1}{2}$ tons per sq. in. put upon it for each $\frac{1}{100}$ in. shrinkage allowed per foot of diameter. Thus an allow-

ance of $\frac{1}{50}$ in. per foot, or, say, $\frac{1}{16}$ in. in a tyre of 3 ft. internal diameter, would involve an initial tension of about 7 tons per square inch. But in practice there is no such thing as a perfectly rigid wheel, and even with strong wheels of the ordinary construction, the amount by which the wheel would be compressed by the application of the tyre, would probably be sufficient to reduce the strain just mentioned to 4 tons per square inch or less, an amount which is, perhaps, scarcely as great as is required. The above calculation of the strain produced by shrinkage is founded on the supposition that the steel of which the tyre is composed will stretch about $\frac{1}{12500}$th of its length for each ton per square inch of tensile strain within the limits of perfect elasticity. If the tyre is composed of harder material the initial strain put upon it by the shrinkage will, of course, be proportionally greater. The increase which has been made in the hardness of tyres has thus rendered excessive the amounts of shrinkage which were fixed upon when the tyres were made of a softer class of steel. Moreover, the use of steel tyres has led in many instances to the employment of stronger and more rigid wheels than formerly, and this again has been the cause of an increase in the initial tension due to a given amount of shrinkage. In America, where steel tyres were sometimes applied to cast-iron wheels of a very rigid kind, it has been found necessary to employ much smaller amounts of shrinkage than are usual in this country.

It is a very common thing to ascribe the breakages of tyres which occur in winter to extra tightness caused by the cold; but we consider that the influence of temperature in this way has been greatly overrated. It must be remembered that if the tyre shrinks, the wheel shrinks also, and it is only any excess of the latter shrinkage over the former which can give rise to increased strain. One very important action of the frost is to make the permanent way more rigid, and thus increase the shocks and jars to which the tyres are exposed, and it is in this way, more than any other, that we believe the cold weather increases the number of fractures.

THE POWER AND CAPABILITIES OF WAR ROCKETS.

From "The Engineer."

History abounds with cases of the following kind:—An invention dawns, under the auspices of some enthusiast, who, vaguely dreaming of powers and capabilities beyond his grasp, forces his invention into notice and adoption prematurely. The invention is tried, found deficient in some respects, is set aside, and the inventor summarily relegated to the ranks of dreamers, quacks, and charlatans, with which sensible people had better have nothing to do. Meantime some collateral aid is undergoing development—some new power is coming into existence, which, if it only had been known simultaneously with the now abandoned invention, would have made it, not perfect, indeed—for what thing on earth is perfect?—but sufficiently adapted to the end proposed. If we do not err, the history of war rockets in Europe affords a case in point; not that war rockets are abandoned, or near abandoned, but, viewed from Congreve's stand-point, they have fallen somewhat into disrepute. We say in Europe, for rockets had been used in China and Burmah as war projectiles long ages before Congreve turned his attention to the perfecting of this powerful but somewhat erratic arm. Congreve was an enthusiast, as every inventor ought to be. Many—we will even say *most*—of his hopes and aspirations in respect to the capabilities of war rockets have not been borne out. The proposition he was never weary of repeating, "That war rockets comprehend the power of artillery everywhere, with the weight of artillery nowhere," is so manifestly untrue that we would not for one moment endeavor to uphold it. Rockets have not, in the first place—and no reasonable man, keeping mechanical principles in view, will expect them to have—the accuracy of cannon, especially rifled cannon; but when this has been admitted little remains to be said against them. Rockets, notwithstanding their deficiencies, have taken their stand in many services. We use them with effect, so does Austria. In mountain war-

fare, such as we had in Abyssinia, their utility is incalculable, as they are easily conveyed over obstacles that to guns would be impassable. Against troops in the open, and more especially cavalry, rockets, when they do take effect, are beyond endurance horrible. At Leipsic the only English troops present were the Congreve rocketers; and though the rockets of that early date were imperfect things, with side-sticks, like ordinary pyrotechnic rockets, their effects were so terrible that the enemy against whom these then new missiles were directed laid down their arms.

Having said this much in favor of war rockets, we are to be understood as vindicating their claims to utility, even though no better than Sir William Congreve left them; but it is well known that since Congreve's time rockets have undergone some great and advantageous mutations. Amongst these we must not forget the increased accuracy imparted to rockets by the various devices of Mr. Hale, who, in doing away with the stick altogether, and imparting rotary motion by tangential fire-vents, accomplishes a result exactly similar to that effected on shot or shell by a rifle gun, and with similar intent. Practically, we know full well that Mr. Hale has achieved a certain accuracy of flight at the sacrifice of other advantages already conceded to rockets. A Hale's rocket, to accomplish its intended flight, must be fired at a large angle, which, of course, implies the disadvantage of a high trajectory. Again, with Hale's rockets, the ground volley—a mode of discharge most efficacious against cavalry—must be abandoned, at least under the majority of circumstances. Conceding to Hale's rockets the merit of accuracy beyond that of other rockets, these weapons must still be excluded from calculations in respect to some further developments of the general war rocket system, and that for a reason which will presently become apparent. We are of opinion that no war rocket has yet been made to work in accordance with the true genius of the arm, as impressed by a long course of discovery since the time of Congreve. If wars must come; if destructive projectiles must be launched; if fortifications must be destroyed, towns burned, and human beings demolished, then the proposition, as one of means to ends, falls within the study of the application of forces. We confess inability, on any ground whatever, to perceive why the workmen who are engaged in this line of business—military men, soldiers that is to say—must be condemned to the perpetual routine of gunpowder, lead, and steel, when other and better means are at hand. A list of combustible and explosive things have been discovered since the time of Congreve, things to which gunpowder at its very best, or worst, is a trifle. Nitro- glycerine is one of these, and more especially to nitroglycerine do our present observations point. Some people are expectant enough to hope and believe in the discovery of a substitute for gunpowder as a material for gun and shell charges. We are not amongst the number of these. For the above purposes the invention of Schwartz, Bacon, the Chinese, or whoever the real discoverer of powder may have been, is, in our opinion, so good that better need not be desired, and, if desired, could not be found. We have never yet heard of a single explosive body that could be substituted for powder in artillery practice with advantage, and, if even found, the merit of such assuredly will not be in any increase of strength over ordinary powder, seeing that, even now, the old material can even be too strong for the resistance of gun metal. As for nitro-glycerine, even were it less shattering, it could never be used for a gun charge, because of its liquidity. As little could it be used for a gun shell charge, because of inability to withstand the shock of first impact without explosion. Nitro-glycerine, however, could be used for the heading of a rocket. And this being so, again, why not? As well might one urge the forging of anchors with arm-wrought sledge hammers instead of the Nasmyths which have supplanted these baby things, as the continuance of gunpowder—only gunpowder—as a certain means to a certain end, when a better force is available. Let no one suppose we are insane enough to propose the application of nitro-glycerine to rockets as a part of any ordinary armament. If, for example, this dangerous liquid were to be jolted about in ammunition wagons, as ordinary shells are jolted about, it needs no conjuror to predict what would happen. Our remarks apply to specific cases; the capture of a beleaguered city like Paris being one. Since the 20th of September

Paris has been invested, German forces encompassing it all round in a circle of about eighty English miles in circumference. Assuming a deliberate intent to make Paris succumb, if possible, then the case becomes one of means to ends. Its consideration is as free to speculation as the boring of a tunnel or the blasting of a rock. None better than the Germans know that to destroy any one of the French forts by the strongest artillery now in the field is practically impossible. Their only hope of success—a hope that at great cost of life may perhaps be realized—is that by the accuracy of their rifled breech-loaders they will be enabled to silence the French batteries though actually firing through the openings of the casemates. As for battering down the forts by hitting the structures at random, the Germans might as well fire apples or oranges at them as the heaviest shot or shell they possess. This proposition granted, we come to an important consideration—one that tends to equalize the accuracy as between rockets and rifled artillery. Handicapping rockets against artillery, so that a rocket hitting anywhere on a structure should count for the same as a bull's-eye made with rifle shell, then on which side would the preponderance of accuracy lie? Might it not lie on the side of the rockets? At any rate, nitro-glycerine could only be projected as we indicate, and for the purpose Hale's rotary rockets are inapplicable, inasmuch as their spinning motion would be sure to explode the charge. In suggesting this mode of attack we make no sort of apology to those false humanitarians who urge the barbarity of the means. Again and again has the axiom been enunciated until universally accepted, that, in proportion as the means of destruction have received development, so have the aggregate horrors of war decreased.

THEORY AND DETAILS OF CONSTRUCTION OF METAL AND TIMBER ARCHES.

By M. JULES GAUDARD.

From "The Artizan."

Elastic arches supporting a road or railway were connected to the horizontal platform by pillars and filling pieces, occupying the spandrels. The office of these parts was to transmit the load of the platform to the resisting arch; no other function was usually attributed to them, and the arch was the important member on which the whole rested. The spandrel, however, forming always a rigid filling or system, contributed powerfully to increase the resistance of the structure, so that it would be justifiable to consider as the chief member, not the isolated arch, but the framework, more or less complex, constituted by the arch, the spandrel filling, and the longitudinal horizontal piece placed at the level of the platform. Under this point of view, the arch might be assimilated to a chain of articulated segments, presenting two modes of calculation which were severally examined. In the articulated system it was necessary to choose a single triangulation, where every piece was essential; for otherwise, if, for example, two diagonals were introduced in each bay, the calculation would become indeterminate. At the summit, the two half-spans were joined by a simple point of articulation, like those of the other summits of the triangulation, while the longitudinal horizontal piece was useless in theory; and in practice it would be desirable to provide it with a free sliding joint, in order that nothing might impede the expansion of the fixed portion. Under these conditions, the elements of statics furnished easily the stresses on all the pieces, of which an example was given. When the stresses in the various parts of the arch or of the longitudinal were known, the stresses in the spandrel bars could be deduced by simple graphic decompositions, based on the equilibrium of the summits of the system. Of this also an example was given, with further calculations. For a determined fixed load there might be given to the arch the form of a funicular polygon, a figure of equilibrium such that the articulated chain might maintain itself in position without the intervention of the other pieces of the framework. In a bridge the load varied, but it was desirable the figure of the arch

should approach that of equilibrium corresponding to the complete load. This form would be the curve called the catenary for an arch of uniform section carrying only its own weight, and the parabola for an arch loaded uniformly per unit of length on a horizontal line. This latter was the case in suspension bridges, and also in bridges with compressed metallic arches, for the weight of the arch and the spandrels had but little influence, proportionately to that of the horizontal platform and its test load.

The second mode of calculation referred to rigid arches, and consisted in restricting the spandrels to simple supports for transmitting the loads. The arch was then more strained, and ought to be rigid, for the funicular form only gave an instable equilibrium, corresponding to a particular state of the load. As soon as this state was changed, the arch no longer suffered simple compression, but was disposed to bend, *i. e.*, to change its figure. In an arch of masonry, the effect of the mortar was neglected, and the voussoirs were regarded as blocks placed in juxtaposition without adherence, having the power of pivoting one on the other, round the edge either of the intrados or of the extrados; that was what was called a system of alternative articulation. The centre of pressures, *i. e.*, the point of application of the resultant of the elementary reactions of the joint, was considered for each joint. The locus of these centres, or the curve of pressures, ought not to pass outside the thickness of the arch, or the pivoting of certain of the voussoirs would take place; the curve ought even to keep within a zone more limited than that of the arch, for fear of endangering the crushing of the stones. An elastic arch was subject to other conditions. If the connection was very good, as was (or ought to be)the case with plate iron, the arch formed an entire piece, suitable to resist both tension and compression. If it was treated as an arch by the curve of pressures, this curve would no longer be required to remain within the arch. When the arch rested upon the abutments by an extending sustaining surface, being keyed by a range of wedges, there was nothing to prevent certain of these wedges being driven tighter than others. This would then modify the point of concentration of the thrust upon the abutment, and consequently also all the other points of the curve of pressures. Hence arose the uncertainty which generally attended the method of the curve of pressures, these pressures only being determined by arbitrary data in regard to the original keying up, or the yielding of the materials. The author considered the proposal to provide a metallic arch with three pivots, or hinges, one at the summit, the other two at the supports; but hitherto, so far as he was aware, no one had ventured to apply three pivots to large works. M. Mantion had, however, employed two pivots at the supports in an iron bridge of the St. Denis canal, and the effect of such a system was examined. The theoretical calculations of deformation might be applied with confidence, where the arches consisted of a single piece of homogeneous metal. Arches in solid wrought-iron plate might be considered to belong to this category, the metal having been well worked, and the connections being as solid as the continuous parts. The theory of these arches had been the object of the researches of M. Bélanger, and subsequently of M. Bresse, who had entered into great detail respecting them in his treatise on Applied Mechanics (Stabilité des Constructions). An explanation of his principal formulæ was then given. The author next proceeded to consider the details of construction of arches of different materials. He remarked that structures in timber were the most economical in many countries, but their durability was limited. The principal type of timber arches appeared to be that inaugurated at Yvry (Seine) by M. Emery, where the arches were composed of strong pieces of carpentry superposed to the number of three, for example. But it was preferred in many cases to leave open the intervals between the several pieces, in order to allow better ventilation, and to prevent them from heating; and further, because this plan gave an increase of depth to the arch, and consequently a more ample field to the oscillations of the curve of pressures. Certain timber bridges presented a compressed arch, a tensile tie-bar, and vertical connecting-rods, a system which was allied to the bowstring form. The flat arches of Wiebeking (Bavaria), and those in thin layers of planks superposed of Emy, would appear only suitable for roofing purposes, being too subject to deform-

ation for bridges. Among the American forms of trellis framework for straight beams, capable of competing with arched openings, the system of Howe, having iron vertical tie-rods, deserved special mention. Cast iron resisted compression well, but tension badly. It made good arches in the cases where the curve of pressures did not pass out of a certain central zone, and where the flexure was nothing, or insensible; and on the condition that there were no powerful vibrations, *i. e.*, that the dead weight was large compared to the moving load. This last consideration led, in the case of railways, to the spreading of a thick layer of ballast on the platform, in spite of the increase of load resulting therefrom. Wrought iron was preferable to cast iron, notwithstanding its higher price, whenever there was reason to fear the effects of flexure in certain parts, or when it was desired to make a light structure, without loading of ballast. There was also an opportunity of adopting pivoted supports, and of calculating the thrust according to the theoretical deformation. However, this conclusion was not absolutely true for trellised arches, which it was necessary to use in the case of very large spans. Such, for example, was the bridge at Coblenz over the Rhine, consisting of three arches, each 317 ft. span. In general, a solid plate web was preferable to trellis-work for arches of moderate dimensions. In effect, the flexure was small, and the longitudinal pressure much predominated; the solid plate acted, consequently, more usefully than in a straight beam, which presented neutral fibres. Moreover, it would only be necessary to employ rivets at considerable intervals in the parts outside the joints. To satisfy the most advantageous condition, viz., a large moment of inertia, without too great depth, it was desirable to adopt for the section a double T with large wings. For large openings, however, a box section appeared to be preferred. The lateral stiffness would depend essentially on the cross framing which connected together the different arch ribs of the same span. Where this resource was wanting, *i. e.*, where an isolated arch rib must maintain itself alone, the oval section analogous to that of the arches of the bridge at Saltash, presented itself as one of the most favorable. Wrought and cast iron might be associated in the same work. This combination had been adopted in a bridge of three arches constructed in the park at Neuilly, near Paris, many details of which had been suggested by the new Westminster Bridge. All the pieces essentially under compression, *i. e.*, the spandrels and the portions of the arch near the abutments, had, for the sake of economy, been made of cast iron, while the central portion of the arches and the longitudinal bearers of the platform were of plate iron. Arched bridges were, on principle, often more economical than those formed with girders; they admitted better of an augmentation of the dead weight, for the purpose of deadening the vibrations and increasing the probable durability. But it was necessary that sufficient height should be available, and that the abutments should be able to resist the thrust. When the work was low and the ground solid, it was easy to give the abutments the necessary stability, without too much expense. The compression, tending to close the molecules of the metal, appeared to promise to such works a longer duration than would be due to pieces in tension, which threatened, after a long period, to be subject to enervation. These considerations in favor of arched bridges were, it is true, somewhat counterbalanced by the greater complication of the forms. Bow and string bridges were, as the words implied, arches provided with a tie-rod which received the thrust upon the extremities, without the intervention of supports; so that the abutments were freed from the effect of these thrusts, and only exerted reactions in a vertical direction. The most remarkable example was the bridge at Saltash, of two great spans of 456 ft. each. The arch, being single, had to be kept at the two ends at the height above the roadways necessary to leave a free passage for the trains; and this led the eminent designer, Mr. Brunel, to adopt a curved tie, and to suspend the platform at a lower level. When there were two arches, one on each side of the road, there was nothing to prevent their extremities descending to the level of the platform; the tie was then straight, and being strengthened in order to serve as a longitudinal bearer, it might support the roadway. An example of this disposition was the bridge of Audenarde, on the Scheldt.

In conclusion, the author referred to a work he had published in 1865 ("Etude

comparative sur les Ponts en Fer,") in which he had given formulæ expressing the stresses on the various parts of bow and string girders, as well as the comparison between this and other systems of construction.

BOOTH'S PATENT RAIL.

This rail consists of an iron base with a steel cap, united to the base, not by bolts, screws, or rivets, but simply by clamping. The iron bar is rolled to the required form and weight, after which the steel cap, having been rolled of the proper form and length, is properly tempered and placed upon the cold iron base. The two are then passed through the Compressing machine, which presses the cap down upon the base and clenches in its side. A good fit and a fast hold are thus obtained, with a powerful shrinkage.

To remove the steel cap for refitting or other purposes, the iron base is firmly secured, and by a hook on each side of the cap a separation is formed at one end, and followed through by rolls the entire length of the rail.

Patents have been obtained upon this rail in the United States, Great Britain, France, and Belgium. By the original patents there is secured to the inventor the sole and exclusive right to manufacture, use, and sell rails, composed of the iron body and steel cap, when the latter is rolled and shrunk on the body in such a manner as to unite the parts closely as a unit or whole, but still allow them to be easily separated and replaced. More recent patents secure the use of the combination of the cap and base, with depressions or indentations in the base, as found desirable.

This feature of clamping the cap around the head of the iron base, is thus recognized by the Patent Office as a new and original feature. Other compound rails have been made of iron and steel, but in all cases the steel and iron have been united by rivets, bolts, or welding. These have all proved defective. Besides other causes of displacement, the variation in climate of 125 deg. annually, expanding and contracting the iron and steel differently, has been found sufficient to cut off the rivets and tear asunder the welding. Booth's arrangement obviates this difficulty entirely, by allowing the cap to slide sufficiently on the rail without displacement or injury to either material.

In this form of rail are combined, it is believed, all the advantages of both iron and steel rails, with others that would alone render it superior to either. Notwithstanding the prevailing tendency to extol the merits of the steel rail, there is no doubt that the iron rail possesses some obvious advantages over its rival, and further experience of steel may show that it has others. Its obvious advantages are:

1. Cheapness of cost.
2. Greater elasticity under travel.
3. Capability of being made over.

To offset these, there is claimed for steel rails so much greater durability as alone to render them more economical on the whole; but whether this will prove to be the fact in view of their special disadvantages, can only be determined by experience. These disadvantages are:

1. Greater first cost.
2. Greater rigidity under work.
3. Liability to break.
4. Incapability of being made over.

The 1st and 4th of these disadvantages are of obvious weight in the consideration of economy. The extent of bearing of the 2d and 3d cannot at present be accurately estimated. There can be little doubt, however, that the greater rigidity of the rail (which is apparent, even to the traveller over it, by the harsh and disagreeable grating sensation it produces) depreciates the rolling stock more rapidly. The granite ties or stone work upon which railways were first laid, are, for this cause, now universally discontinued. With regard to the breakage of steel rails, we have some evidence furnished in a late report of the President of the Michigan Central Railroad Company, James F. Joy. He says (see Report, 1868, page 7):

"Three miles of steel rails have been laid, and thus far they have hardly borne the test, having been found more liable to break than iron."

These rails are of the best English made

Bessemer steel. Also, in the report for 1868, of the President of the Chicago B. & Q. R. R. He says:

"We have laid about three miles of steel rails where they will be subject to the greatest wear, in order to test their quality and durability, as compared with iron. The result thus far has not been such as to encourage the Board in an extended use of it in the ordinary track of the road."

Thus it appears that the only certain advantage that the steel rail possesses over the iron, is its greater durability.

Our next inquiry will be to compare the Booth rail with both the others, in respect to the qualities above considered:

1. Cost.—The first cost of the Booth rail is much less than that of steel, though of course, greater than iron. But it has been suggested that *in case* steel should be hereafter made as cheap as iron, that this advantage would be lost. We contend, however, that even in such an improbable event, the Booth rail could still be made cheaper than the steel, inasmuch as vast quantities of old iron rail, from which it could be made, would then be inevitably on the market, at prices much below their usual standard of value. This can be worked over into the iron base of the Booth rail, and the whole rail thus be made at a less cost than steel rails from new material.

2. Durability.—Supposing the cap to remain firmly in its place (a point which we shall consider hereafter), it is evident that it will wear as well and as long as any other steel surface. The thickness of the cap being about one-half an inch (and more if desired), it will only wear out by the same abrasion of surface as would render a solid steel rail useless, especially as this abrasion would not be uniform but irregular. The *first* wear of this rail, therefore will be equal to that of the steel rail. What that wear would be, may perhaps be pretty nearly estimated. English experience establishes the fact that a steel rail will outwear seventeen iron rails in the same service. It is also stated that it takes 11,000,000 wheels to reduce a steel head 7 lbs. to the yard—there being no lamination, but a uniform wearing away, as by friction. If these reports are true, it would take forty years to reduce 7 lbs. to the yard, upon the straight portion of any principal railway in the United States.

The Booth rail, as now made, has 15 lbs. steel to the yard, and after a uniform reduction of 7 lbs. to the yard, it would still be serviceable.

In point of exemption from liabllity to breakage, it is evident that its advantages are at least equal to that of the iron, and therefore, as we shall prove hereafter, superior (in all probability) to steel. We are now considering economy merely in the light of the durability (or life) of the rail. But this exemption from liability to breakage has a more important bearing on the question of economy, by its result in freedom from accident. And we shall, therefore, examine the subject further, when we come to consider the special advantages of the Booth rail, with reference to safety.

3. Capability of being worked over.—In this respect the Booth rail enjoys a great superiority. The steel rail once discarded, is useless; and even the iron rail must be taken to a distant rolling mill and re-rolled at great expense. But the Booth rail can, by machinery that will not cost over $15,000, and which every railroad company can afford to own, be at once re-capped at a comparatively small expense.

4. Elasticity under Travel.—The base of the Booth rail being of iron, exhibits the same advantage in this respect as an iron rail. The extent of this advantage in its effect upon the wear of rolling stock, as well as upon the comfort of the travelling public, we have before suggested, can only be fully ascertained by experience. When it is remembered that the steel rails in use are three times as stiff between ties as iron, it will be apparent that the effect of this increased rigidity *may be* considerable, and the advantage of an iron base is, therefore, well worthy of consideration.

Other Special Advantages—Safety.—It thus appears that the Booth rail possesses the combined advantages of both the simple rails, and that in the important quality of economy, it is far superior to either. Is is also superior to either in the no less important quality of *safety*, for, being a duplex rail, it cannot break unless flaws in both parts should come together, which is to the last degree improbable. Hence either part may break

without danger of immediate accident, giving an opportunity to substitute a sound for the broken rail. The numerous accidents, some frightful, and all expensive, that have occurred during the last few years, from broken rails, will attract to this advantage of the Booth rail, a serious attention.

It would seem that the steel rails are more liable to breakage than iron. Much skill is required in their manufacture, and there is thus more danger of flaws, or burning, or imperfect temper. Many have, in fact, broken from being made too hard, and it is certain that in casting the ingot of Bessemer steel, many crack transversely. These flaws, in many cases, even if extending half through a piece of steel (60 lbs. to the yard), would hardly be discovered, even by a sledge-hammer test. Yet, with a 40-ton engine, on a cold night, there would too probably be a different result. Flaws might also occur, and undoubtedly do, in the Booth steel cap, but as this weighs only 15 or 16 lbs. to the yard, the test of the hammer, which is always applied before its application to the rail, and the further test secured by the process of rolling on the cap, are sure to discover the defect, and even should these both fail, there is, as already observed, an additional security in the strength of the iron base. It is a well known fact, that iron and steel united, cannot be broken as easily as the same size piece of either separately.

In this connection we may add that the strength of this rail has been practically tested in comparison with iron and steel rails of the same weight, under a powerful press, and shows a marked superiority over both. Attempts to break it by repeatedly bending it in opposite directions proved unavailing.

We have already shown that any railroad company can take up and repair its own rails, at moderate expense, but there is more to be said on this subject. In case a rail fails to wear evenly, or becomes battered or defaced at the ends, there is no need of losing it like an iron or steel rail, or even of taking it up, but the defaced portion can be at once cut out by means of a milling tool, and the rail re-capped in that part without removal.

COAL MINES IN CHINA.

From "Engineering."

The following particulars relative to the coal mines in the neighborhood of Kelung, near Shanghai, have been drawn up at the request of Her Majesty's representative at the latter port. The mines at present in working order are 46 in number, and occupy a tract of country covering an area of some 30 miles to the eastward of the town of Kelung. They produce an aggregate, in the year, of 300,000 piculs, or 17,142 tons, a third of which is exported in 200 junks from Kelung. Some 1,300 miners are employed, whose wages are at the rate of 40 cents a day per man, while those of the porters carrying the coal to the water's edge, average 30 cents. The range of hills in which the coal is found in abundance touches the seaboard at a small bay called Pa-tow-ah, known in the charts as Coal Harbor, 3 miles distant from Kelung. The distance from this bay to the nearest mine is $\frac{3}{4}$ of a mile up hill, down which the coal is brought by porters, and taken thence in junks to Kelung for sale. A navigable creek called Tienlias Kiang, $2\frac{1}{2}$ miles in length, connects the more remote or "inner mines" with Kelung itself. The cost of transport from Coal Harbor to Kelung, by water, is from $1.50 to $2 per 100 piculs, it being influenced by the state of the weather; while that from the inner mines along the creek to Kelung is about $1 per 100 piculs, the boats used carrying 150 piculs or 8 tons. The price of coal at the pit's mouth is quoted at $13, and at Kelung it ranges from $16 to $22 per 100 piculs, that is, from 13s. to 18s. per ton, the latter price being paid for the very best picked coal. The coal is found within a very few feet of the surface, and the mines are, in most cases, worked into the side of the hill in nearly a horizontal direction, and the water which accumulates therein is thus enabled to run off easily through the entrance. In some instances, however, the strata dip slightly inwards, and then pumps, on the same principle as the chain pumps seen in the paddy fields throughout Southern China, are employed, which,

worked by 3 or 4 men, raise about 25 gals. of water per min. This contrivance answers well enough for the little drainage necessary. The depth of the mine hardly exceeds 500 yards, as, when the vein is worked through, it is left ; its height at the entrance is from 3 to 20 ft.

The lamps used by the miners are merely small saucers with oil, and a wick protruding over the side, one end of which is lighted, and the saucer placed in a niche in the side of the mine. Fire-damp seems unknown, though no special means are employed to secure ventilation. The proprietors of the mines are, as a rule, the descendants of the first settlers, after the expulsion of the savages ; the heads of the clans, some 20 years ago, petitioned the officials to prohibit the working of the mines, for fear of the ill-luck which would, as they said, result ; but the payment of a slight tax sufficed to overcome any opposition at that time. The obstinacy of the officials, combined with the want of proper mining ability, has hitherto impeded the working of the most productive beds of coal, said to lie beneath the level of the river leading to Kelung. The proprietors state their unwillingness to sell or lease the mines to foreigners without official sanction, and their capital does not admit of their employing foreign machinery. The tax levied on the exportation amounts to $2.40 per 1,000 piculs, or 2½d. a ton, the picul being estimated at 128 lbs. The chief faults found with the Kelung coal are, that it burns too quickly, and generates an enormous amount of smoke. If properly mined, however, these defects are said to disappear ; and some has been obtained which was considered to be but 25 per cent. inferior to the best Welsh coal.

ON THE SELECTION OF BUILDING SITES.*

From "The Builder."

Buildings are, of course, constructed on all kinds of sites ; but for many reasons modern towns generally occupy valleys, and are thus distinctly contrasted with towns of other days, which were much more commonly, and for equally good reasons, perched on eminences. Valleys now traversed by rivers are far more convenient than plateaus, as more accessible both by land and water, and if less safe in a military sense than plains in some respects, they are much more so in others. But whatever the reason, it is a fact that all important and large cities are on or very near large rivers. Thus the condition of the rocks on the surface of valleys has important significance.

It may be assumed, in the present state of geological science, that all such open valleys as now form or contain the beds of rivers, have been reduced to their present shape, and have derived their present condition from the passage of water through them. The beds or bottoms of the valleys have been cut out by water, the transported material with which they are covered has been moved by water, the cliffs or slopes of the enclosing hills, at whatever distance, have been brought into their present state by weather action, and small as the stream may be that runs along a narrow channel in a winding course between these cliffs or slopes, it has been sufficient in the course of time to bring about the result we see before us. All that lies immediately beneath the surface in the valley, often to a great depth, consists of material removed very gradually by this water, while below that there is often another deposit of water-transported material, consisting of clay, stones, and sand, due perhaps to ancient glaciers, or left behind by icebergs that have floated over or have been stranded upon it when many fathoms below the sea level. Sometimes there are streams entering the main river from side valleys, and each of these again has formed its channel and left its mark. The more sluggish the main stream, and the further it is from its source, the greater in proportion is the effect of such feeders. When they are torrents they sweep all before them, and deposit large stones with smaller gravel, clay, and sand. When they have had a more even course,

* From a paper by Professor Anstead, F. R. S., read at the Royal Institute of British Architects.

they deposit fewer large stones and more mud and sand.

From this account of the history of river deposits, given in a very few words and requiring to be varied in detail for every stream without exception, you may understand the nature of the material that you have to deal with in preparing foundations for a large and massive construction, in almost every part of England where such buildings are likely to be erected. The clay you find may be alluvial clay deposited by the stream, or it may be boulder clay left behind by ice. It may thin out at any point, and give place to gravel, to loose stones, or to fine sand. Beneath it may be a quicksand. A certain number of tons pressing on the square foot of surface may and will cause the clay to slip away from the sands, or the run of an open drain through such sands may, by removing them, remove all support. When in the bed of the main stream, there may be a very regular deposit of clay, capable of supporting any weight that could be put upon it, but the intervention of one of the old and forgotten tributaries may have cut away part of this clay for an interval, or prevented its formation, and thus one part of a building may be on a good clay and another part on loose shifting sand.

It is exceedingly important that the exact physical conditions of the formation of the alluvial beds of rivers should be clearly understood by practical men. It is by no means the case that the present bed of a river is the only part where loose and uncertain material exists, nor is it at all necessary to assume any change of level, still less any great convulsion of nature, to account for the phenomena. They may be studied in every valley where the stream is left to take its natural course; but in England, and in many other countries where land is valuable and cultivation carried on extensively, the rivers are never left to themselves, and, therefore, the changes that explain and illustrate these conditions are not perceived. In a natural state a river rarely follows the same course through its valley many seasons in succession. Either it chokes up its old bed and steps aside to form a new one, or, owing to a torrent, it cuts itself a new course altogether, and leaves the old bed dry. All our river beds have been formed in this way. It is not that the quantity of water brought down varies much, but that the circumstances change, and new channels are cut, the deposits of course shifting. The whole width of the valley through which a river runs is of the same nature, and the deposits are due to the same cause. Hence, the variety in the foundations in different parts of the valley far removed from the present course of the stream, which has not, perhaps, been allowed to shift for many centuries.

But in addition to ordinary alluvial bottoms resting on clay, limestone, or sandstone, as the case may be, and consisting of the usual admixture of sands, clays, and river gravels, are the instances in which the river valley has been ploughed out by the action of the ice, and has received large deposits of boulders, boulder clay, and the usual accompaniments of fine and course sand and gravel. Gravels are frequently found at levels very much above the bottom of the valley, and they not unfrequently even cap the hills through which the river is cut. The same kinds of gravel often occupy the valleys themselves.

Excellent as gravel is as a foundation when in sufficient quantity and uniform in texture, it can hardly be trusted unless its history be known. The gravels called diluvial are often comparatively free from loose sands and clays, and are then excellent for every purpose required by the architect or engineer. They are sound, well drained, healthy, and generally yield water at a small depth. But it is not so with the gravels occasionally found with boulder clay, nor with ordinary river gravels, and thus, as I have already pointed out, the history of gravel is an important inquiry when it is proposed to construct buildings upon it.

Natural drainage is very important in all large buildings. Without this, even if the foundations are sound, moisture will rise up by capillary action through almost every variety of stone and brick, and will in time deface the building and increase the action of weather on the surface. Certain rocks drain naturally, and are safe. Others may be drained with little difficulty, and may be made safe. Others, again, will tax the ingenuity and experience of the most accomplished architect, and will, after all, be only partially cured. There cannot be a

doubt that in this latter, and also in the second case, the constructor would be greatly assisted by knowing the nature of the enemy he has to deal with, and this can only be done by a knowledge of rocks generally and of the local geology.

Very important questions arise in reference to the relative influence of certain rocks on the sanitary condition of the buildings erected upon them. Thus, in a general sense, it may be considered as proved by experience that clay soils and other impermeable material near the surface are less healthy than well-drained sites, and more liable to attacks of fever, and that permeable soils and gravel are dry and healthy. There are, however, important modifications of this view, dependent on the subsoil and underlying rock, which are often out of sight and below even deep foundations, and here a knowledge of geology becomes necessary to the architect. It is well shown by Professor Pettenkofer, of Munich, that in certain cases where bands of clay intervene in gravel, the presence or absence of fever in the population corresponds exactly with the existence or otherwise of these impermeable deposits. In other words, even where the general subsoil enjoys a certain amount of natural drainage, the healthiness of the site depends strictly on the condition of the rocks at a considerable depth, and that stagnant subsoil water, even when its presence cannot be detected by ordinary observation, makes itself felt in a very serious manner.

In speaking of the applications of geology, I have avoided the mention of particular rocks as much as possible, because it is not so much the rock as its condition that affects the practical man. I have known granites porous and absorbent, limestones compact and non-absorbent, sandstones offering every possible variety in every respect, and even clays very different in different places. What is wanted is such a general acquaintance with the principles of stratification and the nature of rocks as shall enable the architect or builder to make the best use of the conditions he has to deal with. I cannot lay down rules that can be made use of without further trouble; I can only point out the key which will unlock the difficulty in each individual case, if it is applied properly and intelligently.

Water supply from springs, either at or moderately near the surface, is a very essential matter in the case of buildings intended as habitations removed to some distance from pure running water. But it is now well known that however pleasant clear spring water may be to the taste, it is capable of containing, and does in certain cases contain injurious ingredients sufficient to render it a fatal poison. There can be no doubt that certain superficial deposits and certain rocks are liable to induce this state in the water, while others are not. It is evident that the causes of events of this kind should be known to the architect, and it is highly desirable that he should be acquainted with the theory of springs, at least of such as are likely to affect buildings. Absorbent gravels resting on non-absorbent rocks may be expected to introduce poison into water when the ground is liable to be covered with decomposing animal or vegetable matter, or with sewage, for the rain entering them cannot fail to carry in water loaded with as much of such impurities as it can contain. Such of them as are soluble in water will certainly therefore mix with it, and render unwholesome all the water pumped from the bottom of such a deposit.

On the other hand, where water has a free exit from rocks, it is almost impossible that such injury can take place to any great extent. Land springs and Artesian springs from basins are dangerous. Springs from hill sides, or Artesian springs reaching water tapped in its progress to an outlet, are generally safe. How is it to be known what is the nature of the springs without some reference to the science of geology, and some knowledge of the laws of superposition of rocks?

The whole subject of the weathering of rocks deserves the careful study of all who have to deal with stone and brick. All material, without exception, is affected by exposure; but while some will remain almost unchanged, and even hardens when left to the action of the air, other kinds will at once decompose and rot. It is not always the hardest that is the best. This is especially the case with flags or stones splitting with parallel faces. Many very good flagstones are formed by the exposure of quarried and squared blocks during one winter, and then in the following spring splitting the mass by wedges in the

cracks indicated. If left longer, they can no longer be split with advantage; and after a time it becomes impossible to split them at all. Something of this kind happens with all stones. After being quarried, stones are for some time in the state called green, and after exposure to a certain extent they are said to be seasoned. In the latter state they are regarded as fit for use; but, after all, it is doubtful, without experience, whether they will be permanently sound. It is evident that if the architect and builder knew more of the history of stones he would be able to use them to better advantage.

The study of stones in the quarry, and a careful examination of the effects of weathering and disintegration by the action of rain and frost of the same stone in the immediate neighborhood, whether naturally exposed or placed in buildings of any kind, combined with a knowledge of the chemical composition, the peculiarities of aggregation, and the natural history of the stone itself and the beds with which it is associated, will very often suggest to the intelligent observer its probable weak points for the special service for which it is designed. There are accumulated stores of information of this kind that should be familiar to all who have to decide on the selection of stone, and it should be remembered that stone is in the nature of things an altered form of a very miscellaneous deposit, and that, without especial care in selection and placing, it is next to impossible to secure a large quantity of perfectly even quality.

You will observe that I have included a great variety of details as included within the very important subject of building sites, but I trust you will not think that I have done so without sufficient reason. I am well aware that in modern constructions beds of concrete play an important part in forming artificial foundations, and are much trusted to in keeping out damp and preventing unhealthy miasma. I wish to point out that, however useful such an avoidance of the difficulty may be, it should not be trusted to implicitly, and I think it would be easy to show that there are cases where the danger and mischief would only be postponed for a time by such contrivance, and would reappear and act with full force when by irregular pressure on a bad and shifting subsoil the concrete becomes cracked and crushed long before the time has come when the building would begin to fail by reason of age and general wear.

I assume as entirely beyond discussion, that in the exercise of his profession the architect desires only to do justice on the one hand to his own inventive genius, skill, and reputation; on the other, to the highest interests of his client. I have endeavored to show that in order to do this he must inform himself concerning, and be to some extent familiar with, the principles and applications of the science of geology as now understood. He must from time to time call in the aid of this science to decide matters of vital importance, and he cannot do so properly without making them a subject of serious and special study. I have not entered into details, as they could hardly be fitly discussed in this place, but I have endeavored to illustrate and explain the principles to which I think your attention as architects should be directed.

Since this memoir was in type, my attention has been directed by my friend, Dr. Letheby, to a pamphlet by Dr. Pettenkofer, in which attention is drawn to the great influence of subsoil and rock on certain diseases, especially cholera and typhus. Dr. Pettenkofer points out that in the case of Gibraltar and Malta it was proved by British statistical returns that at a time when cholera was raging over a large area, there were certain small localities that escaped. On investigation it was found that, whereas the subsoil to a great depth, and, in the case of Malta, the rock, was eminently porous and permeable, the spots that escaped were situated on impermeable clays.

There can, indeed, be no doubt that the health of a town is greatly influenced by the condition of the rock and soil on which it is built, and that generally a moderately porous soil, admitting of the removal of moisture by drainage, is conducive to health, especially in a damp and comparatively cold climate, like that of England; and also that with us gravel and limestone as subsoil and rock are healthy as well as pleasant. But it is equally certain that where the underlying rock is deep and permeable, admitting of a considerable alteration of level of that surface of permanent wetness which is sure to exist at some depth or other under

such circumstances, but which varies with the season, the result may be different, and it may require both knowledge and judgment to decide as to the relative value of sites, even with regard to water only. It is also true that wherever there is a great collection of human beings, living over a permeable soil and rock, the effect of the accumulation of refuse and sewage cannot but be felt in the course of time. The water percolating from the surface will carry down organic matter, and this in time will make itself felt by generating unhealthy vapors occasionally reaching the surface.

But there is another question to be considered, which in warm and dry climates rises into great importance, and with regard to which the observations of Dr. Pettenkofer are very suggestive. All rocks are capable of absorbing, and therefore usually contain a certain quantity of atmospheric air, either in its normal state or replaced by other gases. No doubt a certain change in the constitution of the gases absorbed may take place, in consequence of an action well known to take place in porous and spongy solids when mixed gases pass through them. The quantity of air or gases contained in all rocks must vary, and must be affected by changes of weather. During dry and hot weather large quantities are given off, and during colder weather re-absorbed. In rocks, then, that contain much air, either in consequence of their great absorbent power, or their mass when there has been received into the body of the rock by percolation from above any quantity of organic matter, and this organic matter has become putrid, the gases given off during hot summer days are liable to become dangerous miasma, and when cholera and fever are prevalent, are especially liable to communicate infection. I cannot but attribute to this cause the extremely bad sanitary state of some districts in the Mediterranean—healthy enough so long as there is rain, but poisonous in the dry autumn; and in these cases I can easily understand that the intervention of even a small and thin band of clay may be a source of safety, and the more so the nearer it is to the surface.

I need offer no apology for pointing out these facts and inferences in a memoir on the subject of building sites, and of which the application of geology to architecture is the professed subject. Sanitary considerations connected with, and arising out of, topographical and geological positions, can never be dissociated from the practice of architecture, and I am sure you will agree with me that all knowledge that can help to a conclusion in such matters is not only desirable, but ought to be considered indispensable to the architect.

ON THE STRENGTH OF LOCK GATES.

By WALTER R. BROWNE, Assoc. Inst. C. E.

From "The Artizan."

The author first alluded to previous communications on the same subject by Mr. Peter Barlow and by Mr. Kingsbury, in the proceedings of the Institution, and remarked that Mr. Kingsbury, in arguing in favor of cylindrical gates (*i. e.*, such as when closed formed a single arc), had assumed the pressure on such gates to be uniform throughout the section, which was not necessarily the case. The external forces common to all varieties of gates were then obtained by the ordinary principles of geometrical mechanics. The most important and complicated case, that of a cambered-iron-plate girder, was next taken, and it was shown by analysis how to find the strains, and consequently the area requisite at any part, first of the central section, and subsequently of any other section of the gate. The result was an equation between five variable quantities, so that four of these being fixed by other considerations, the fifth could be thus determined. These quantities were the two flanges of the girder, the depth and thickness of the web and the camber. The application of the result to the ends of the gate showed that the area of the front flange (or that away from the water) and of the web should be greater at the ends of the gate than at the middle. The question was next considered, how these other quantities should be fixed. The dimensions of the web and front flange

were left for practical considerations. It was shown how, for a given pair of gates, to determine the camber, so that the back flange (that towards the water) should be as small as possible. Lastly, the proper value for the rise or sally of a pair of gates was considered. It was shown that, theoretically, the rise should be such that the gates met at a right angle, but that there were practical objections to this which seemed to reduce the proper angle between the gate and the span to from 25 to 30 deg.

The paper closed by remarking that the double skinned gates, now in favor, were heavier than appeared by theory to be necessary; that wooden gates were short-lived and could not be given much camber, and that a wooden skin, supported by girders at intervals, would appear to be the form best adapted to the requirements of theory and practice.

THE BRITISH NAVY IN 1871.*

The difficulties of European politics all point in the direction of war. We may have hugged to ourselves for awhile the comfortable delusion that our insular position secured us exemption from attack; but we have now to confront realities instead of probabilities, and are compelled to ask seriously, as a question of moment, "Are we ready to meet any eventuality."

The temper of this country has been tried and has not been found wanting, for all classes of Englishmen feel that, if it is necessary to go to war to defend our national honor, fight we will; and although there is an impression abroad that we are solely engrossed with our commercial interests, and too peace-loving to draw the sword, there is a latent force and determination to resist dictation and avenge insult, which, when roused to action, would prove that the might of England, if it has slumbered, has lost none of its puissance, and would be put forth when needful with even more than its wonted vigor and persistence.

The navy constitutes our first line of defence and our strongest force in attack; it is, as it has always been. the right arm of England's power; and never, in our country's glorious annals, have we possessed a more powerful fleet, more complete and efficient armaments, or more gallant and better trained seamen than at the present time.

A retrospect of ten years will be the best way of understanding the present position of officers and seamen in the navy.

Before the days of iron-clads, the force of men required for the navy was much larger than it is now. While in 1860 there were as many as 250 ships in commission, there are not at present more than 200, distributed over foreign and home stations; but whatever has become of the vessels, the officers remain. It is, indeed, certain, that during the last ten years, the ranks of officers have not been much thinned, though the number of men has been gradually reduced. As vacancies have occurred in the ranks of officers they have been filled up, and, as a result, it is found impossible to give them employment. The old days of large squadrons, headed by a three-decker with a thousand men, are over; but, unfortunately for the contentment of the service, these fine old days have passed away too quickly. The naval service has undergone successive changes, during the last ten years, which have left hardly a feature unaltered, and have in each case materially affected the welfare of the British sailor. In the old days sailors were full of frolicksome fun, with a possibility of mischief; a ship would come home and land a cargo of men ready to be fleeced to their hearts' content, and well worth fleecing. The crew of the Hannibal, paid off late at night, twelve or thirteen years ago, included men, each with £50 and £60 in his pocket, who roamed the streets of Portsmouth the next morning without a penny left them. This, however, was not so attractive a sequel to the cruise of the old tar as getting into Devonport and hiring all the cabs in the town for a short cruise round the place, all hands outside, and the inside reserved for any "lubbers" who liked to take them. Happily, those days when sailors were the victims of

* Extracts from a pamphlet entitled "The British Navy in 1871." By Robert Main. London: Smith, Elder & Co.

crimps, are well nigh over, and with them the old seaman has vanished; the old hands of ten years ago are now out of the field; the stoke-hole has superseded the decks and rigging, and the artisan holds a higher rank than the seaman in the navy. Thus, there has not been found much difficulty in reducing the number of seamen, year by year during the last ten years, to something like the limits actually required of service.

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Our navy now consists of nearly 600 vessels, including every class from a cruiser or gunboat to a man-of-war; and there are in active service about 200, now in commission, of which 25 are iron-clads. The most important squadrons in the Mediterranean, the Channel, and the Coast Guard, consist at present of the finest vessels in the navy. It is interesting to trace the progress made in replacing obsolete and useless vessels by those of the new construction; but in reviewing the efforts of the past year to provide new vessels for the navy, two painful circumstances at once confront us—the loss of the Captain and the resignation of Mr. Reed. It is not within the scope of this pamphlet to enter into either of these controversies; they can only be noticed as disasters, marring an otherwise energetic and prosperous attempt to reinforce the navy with efficient vessels. One special point, however, requires attention here, as it is of a very important character.

Shipbuilding in our dockyards had, for many years, been carried on in a fitful, irregular manner; each administration seemed to think itself justified in getting on as well as it could with the ships it found in existence, and when a panic or other causes arose, going in for shipbuilding with violent energy. This fitful policy—arising partly from the rapid and great improvements necessitated by the increased power of the armaments of our war ships—has been, as may well be imagined, the very reverse of what is either economical or judicious. It has led to ships being built in a hurry which were not wanted; to the admission of an excessive number of artisans at one time, and their necessary wholesale dismissal at another; and to the navy being generally in want of ships of the right sort. As evidences of such defects, we have only to refer to the fact of Sir John Pakington finding himself compelled to build, all of a sudden, 15 frigates which became obsolete almost before they were completed; and to the dockyard dismissals of the last three years. Immoderate work, immoderate stagnation of work, and immoderate employment or dismissal of artisans, have been the fruit of this shuttlecock sort of policy. This state of things Mr. Childers has already attempted to set right by laying down what he considers the minimum annual rate at which shipbuilding should be maintained, and by following it out.

After mature consideration, he arrived at the conclusion that to keep the navy up to its due strength in ships, so as to maintain a minimum standard of efficiency, it would be necessary to build about 20,000 tons of shipping annually. This steady increase to the strength of the navy would suffice to supply deficiencies caused by the annual waste or decay of ships, and would obviate the necessity, except in a time of emergency, of resorting to any unusual means for increasing their number. This annual increase he proposed should be divided between the armored and unarmored vessels, by building 12,000 tons of the former and 8,000 tons of the latter class; and with the view of making use of the dockyards and dockyard labor as much as possible, he proposed that about a fifth of the work only should be done by contract. To show how important an addition this annual increase would be to our fleets, I need only state that it represents three new iron-clads, a frigate, a corvette, and six smaller vessels, annually. This would, indeed, be a very satisfactory plan if properly carried out; its cost would be roughly about two millions and a half; in other words, about a quarter of the sum annually voted for the navy would be devoted to the solid increase of its power.

But to understand a little more clearly the advantages of this policy, it is necessary to know, practically, how our navy stands in regard to ships, especially iron-clads, at the present moment. This time last year there were 47 armored vessels of all descriptions, of which 37 were complete and 10 were in course of construction. An enumeration of their names will be all that is necessary, to show in what position we now stand. The 10 new vessels under construction are the Iron Duke, Sultan, and Glatton, at the royal dock-

yards; the Swiftsure, Vanguard, Triumph, and Hotspur, which are being built by contract; and lastly, the 3 new ships laid down by Mr. Childers, the Devastation, Rupert, and Thunderer. This was the condition of our iron-clad fleet a year ago. To show how far the Government has endeavored to give a practical effect to its shipbuilding policy, and what progress has been made during the past year, we can state that of these 10 unfinished vessels, 5 were launched—the Vanguard, Iron Duke, Hotspur, Sultan, and Swiftsure; and, as will be seen by the following statement, 5 new ships were laid down, namely, the Fury, Cyclops, Gorgon, Hecate, and Hydra, all turret-ships; of which 2—the Fury and Hecate—are to be built at the royal dockyards.

We start, therefore, in the present year, with 51 iron-clads, of which 10 are not quite complete; and but for the loss of the Captain, we should have had 52. The finest vessel added to the navy last year is the Sultan, which is not unlike the Hercules, but is superior to it from being able to carry its armament in a way that makes its guns more powerful. The outbreak of war has caused the Government to push forward shipbuilding with great energy during the past few months, and it is by no means improbable that as many iron-clads will be added to the navy this year as were added last year. Great progress has been made with the Devastation, Glatton, and Triumph, and we may expect to hear of their being launched before many months are over.

Before leaving the subject of ships, I ought to notice the launch of the Plucky, the Comet, and Blazer, little gun-boats built like the Staunch, carrying in their bows one gun, mounted and fired after the fashion of a Moncrieff battery. These gun-boats are a great addition to our naval strength; the loss of the gun-boat Slaney, last year, was a misfortune to the service and a loss to the country. It is proposed to build 2 armored gun-vessels at Chatham, the Scourge and Snake, designed probably with the view of acting like the gun-boats on the Seine, near Paris, which did good service in the sortie on the 30th of November; lastly, there are some wooden vessels of various sizes now under construction. The Blonde is an iron screw-vessel, being built at Portsmouth; the Raleigh has just been laid down at Chatham, and is an iron screw-frigate cased with wood; the Robust is an 81 gun screw frigate, on the stocks at Devonport; the Bulwark is an 81 gun screw-frigate, laid down at Chatham a long time ago, which last year it was proposed to convert into an iron-clad, but upon investigation it turned out that the experiment would be very costly and not by any means satisfactory, and the idea has been therefore abandoned. Four small vessels—the Lively, Osborne, Vigilant, and Woodlark—conclude the shipbuilding work which the Government has now in hand.

With respect to our naval armaments, it will not be forgotten that the accident in the Hercules, added to other untoward circumstances, induced Mr. Childers to look closely into the present state of the heavy ordnance for the fleet. Last year he expressed himself satisfied with all guns of a 12-ton 9-in. calibre and under; but suggested that the heavier ordnance for the navy was not satisfactory. The 18-ton gun was not quite trustworthy; but, on the other hand, the 25-ton gun had been proved thoroughly efficient. In other words, while the ordnance of the most powerful and least powerful iron-clads was good, the armaments of the Hercules and Sultan were not altogether satisfactory. Then, again, good as the 25-ton gun was for the Monarch, Hotspur, and Triumph, it is not powerful enough for the new ships now being constructed, such as the Devastation, Fury, and others. For these vessels it has been determined to have at least 30-ton guns, which have yet to be constructed; it is not intended to open competition for guns of this class. The chilled projectiles for the navy are not quite satisfactory, several having burst; competition, therefore, is to be allowed for the best projectile. Captain Palliser, in discussing this question, thought that the failures were not serious enough or sufficient in number to warrant a reopening of the controversy of guns and projectiles; but we cannot be too certain on such vital points in warfare as armament and ammunition, though to enter into a course of experiments heedlessly or unnecessarily, when every round from a 600-pounder costs the country about £9, would be wasteful. It is satisfactory to know on good authority that our service-guns are safe. Cases of

bursting are very few, and there are guns now in use which are in no way damaged after having fired 1,000 or 2,000 rounds. But with the knowledge which recent experience has given that the best gun is one of the safest steps to victory in warfare, we cannot afford to lose any opportunity of placing our naval ordnance in the highest state of efficiency. A step in this direction was taken last year by the issue of an order from the War Office for the construction of a 35-ton gun, which was completed a few weeks ago, and is to be simply an enlargement of the service gun; that is, it consists of a series of coils. We can form some idea of the gigantic size of this gun when we know that the outer coil consists of a bar of iron nearly equal in length to the height of the Monument. This enormous piece of ordnance weighs 35 tons 7 cwt., and will throw a 700 lbs. shot, which will pierce iron armor 15 in. in thickness; the ordinary charge of powder is calculated at 120 lbs. The tube of the gun, which is about 16 ft. long, was brought out of the factory in which it has been rifled and fixed, muzzle downwards, in a pit under a powerful crane; the heavy breech-piece—a mass of iron weighing 15 tons—was heated nearly to redness in order to expand the metal, and the heated mass was lifted and dropped like a cap over the breech of the perpendicular tube. The moderate calibre of the new gun is designed for penetrating, and the shot will probably be three times the length of its diameter. This monster cannon now only requires to be vented and proved to be ready for service, which it is confidently expected to be immediately. The estimated cost is £2,500. Sir William Armstrong's estimate for a 35-ton gun was £3,500, and Sir Joseph Whitworth's, £6,000.

One very important point was taken up last year in connection with naval ordnance, namely, the best way of protecting ships' decks, which are very vulnerable when exposed to danger from a plunging fire. Several experiments were conducted at Shoeburyness, which proved on the whole satisfactory to the navy, by showing that the penetrability of such decks as those of the Monarch and the larger ironclads was not so great as was imagined. Some interesting experiments took place at Liège in the course of the summer, the principal object of which was apparently to ascertain how to increase the durability of small guns, especially those of bronze. MM. Montefiori and Kunzel had invented some new process which was considered efficient; their idea being that by the mixture and addition of phosphorus, old bronze guns might be strengthened, and that with guns, as with men, phosphorus might be found to be the *vis vitæ*—the secret of lasting power.

A very successful and interesting series of experiments was conducted during the past year at Shoeburyness, in order to test the strength of Palliser shells with the heavy naval ordnance, and also the bronze field-gun for India. But the experiments which excited most interest were those with the mitrailleuse; since then the trials of real warfare in the last few months have determined the value of this arm. It is satisfactory to know, in regard to experiments, that the old-fashioned way of testing iron plates has been superseded; instead of using the old smooth-bore gun to test the plates of the Devastation and Glatton, last year, the 7-in. rifled gun was used with chilled shot.

We ought not to omit all notice of the torpedo experiments which have lately been conducted. Some reproach has been cast on the Government, not without reason, for having given too little attention to torpedoes; the subject has now, however, been taken up with vigor, and, after the melancholy accidents at Cuxhaven, will not be abandoned until our shores are protected against a hostile fleet by these formidable submarine engines of defence.

As regards the dockyards, the rapid progress made in the extension works at Portsmouth and Chatham require notice. When these works are complete, they will afford the most ample accommodation for our largest ships; but it will be some years hence. By means of an excellent plan devised by Colonel Clarke, C. B., the Director of Works, the marines have been employed on these works with the most successful results. At the commencement of the year, the reductions which so annoyed the Government and the dockyards, had been effected so as to bring down the establishments to their proper state of efficiency.

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One of the first things Mr. Childers did, was to reduce the staff of one of these

offices. So astonished were the members of the late Board at this, that they asked, on one occasion, how it happened that in a department which they had reluctantly been compelled to increase, the present Board was able, without any difficulty, to make its first reductions. The reply which Mr. Childers gave was convincing: "There was, indeed, a great necessity for writers' work at that office; but a great deal of the work was useless." In fact, it had been found that *by economizing the work it was possible to reduce the staff*, and that the efficiency of the work done was not in the least injured by the application of a little wholesome economy. After all, the whole secret of this and other anomalies which were found to underlay the traditional system of Admiralty work, can be found in the baneful practice of isolation. Isolation of men and work in Government offices is the secret of any want of success in their work, and of the ease with which mistakes are found by men, like Mr. Childers, who are sufficiently determined and energetic to remove them. Isolation has indeed been the bane of the Admiralty departments. In the case already referred to, this is palpable. Here were two branches of the same office, within a shilling cab fare of each other, and both, without knowing it, engaged on the same kind of work. Each of these branches was as completely isolated as though it belonged to some office in no way connected with the Admiralty, and each kept to its own traditions, and its own system of doing work, as though, instead of being only the part of a machine, it were the whole machine itself. But it is possible to carry this complaint further; indeed, it is barely an exaggeration to say that the same state of isolation existed between rooms under the same roof. The feeble and effeminate habit of writing little notes from one room to another can only be explained by supposing that there may be, in public offices, some notion that tenacity to a seat during office-hours is an official duty. Can it be wondered at, that under such a state of things, the business of the Admiralty, in its inner life, should have been obscured in a network of half intelligible correspondence, and that, in its intercourse with the outer world, this same network of correspondence should involve the most ordinary transaction; that personal communication should be avoided, and the practice of putting every trifle in "black and white" almost deified, and that, as a consequence, the most contradictory orders should be constantly given? To remedy these evils it was determined to bring the various branches of the office as closely together as possible under the eye of the Board, with the view of preventing the same work being done by two branches. But another evil had to be remedied, namely, the irresponsible position of the worker. For the highest, as for the lowest, class of work nobody seemed to be responsible. To such a height had this evil arisen, that every paper dealt with by a junior clerk, was so covered with initials before it reached its last stage, that it was difficult to say who could be held responsible for any error which might arise upon it. More than half the duties of each office consisted, indeed, in simply repeating processes which had already been done. To remedy this defect, it was determined to abolish a whole class of senior men whose duties had consisted of little else than checking work which had already been checked. The class below them was intrusted with the responsibilities of its own work, and received a slightly increased scale of pay; but the junior class was not materially affected by this alteration, beyond having a slight increase in responsibility for its work. To revert to the important subject of the navy. With respect to the number and strength of our war-ships, it is clear that a force of fifty iron-clads is not sufficiently strong. Mr. Cobden, the most peace-loving of economists, laid it down as an axiom that the British Fleet should be as strong as the navies of any two European Powers. But, without endorsing his dictum, there can be no doubt that we cannot discontinue ship-building, and that it is necessary to keep up our dock-yards both for building and for repairs of ships, and also to maintain a sufficient force of workmen to meet all the wants of the Service in this respect. Then, as regards officers, it is essential that we should have a staff sufficient, not merely for current requirements, but for emergencies; while, as regards seamen, it is no less necessary that the reserves should be ample and the men efficient. The Government has certainly not departed from its principles of efficiency,

nor, in straining after economy, has it sacrificed any of them. Ship-building is not discontinued; for, as has already been shown, Mr. Childers, acting upon professional advice, has adopted a certain rate which he is determined to keep up year by year; and, to provide for the repairs of ships, as well as for building, an ample supply of men is provided.

The most startling reductions have been made in the ranks of officers; but, upon investigation, it will be found that these reductions will increase, rather than lessen efficiency. And, with regard to the force of seamen necessary for the Service, it is satisfactory to know that it is both efficient and sufficient.

In fact, so far as reforms have yet been attempted, it is impossible to doubt that their tendency is to benefit rather than injure the Service; and to increase rather than lessen its efficiency. There have been errors; but how can they be altogether avoided in the execution of any reform? Such as have occurred are rather in matters of detail than principle, and no attempt has been made, or is even necessary, to conceal them or evade their admission. In the navy, the country wants a service complete and strong in all its parts; which shall be capable of affording protection to our commerce and our interests abroad, and of guarding our own coasts. The old idea, that mere numbers mean power; that large fleets, thousands of men, and acres of stores mean efficiency, has been proved to be erroneous. The Government, in boldly attacking this prejudice, has cleared the navy of what did not represent real strength, cut away masses of useless and cumbrous top-hamper, and at the same time introduced an economy which has already materially lessened the burden of taxation.

The following list of our fleet of ironclads must carry the conviction to all unprejudiced and impartial minds, that we are able to cope with any naval force that can be brought against us:

BROADSIDE IRON-CLADS (36 IN NUMBER).

1. Hercules, Sultan.
2. Audacious, Invincible, Vanguard, Iron Duke, Swiftsure, Triumph.
3. Bellerophon, Lord Clyde, Lord Warden, Minotaur, Agincourt, Northumberland, Royal Alfred, Penelope, Repulse.
4. Achilles, Royal Oak, Prince Consort, Caledonia, Ocean, Valiant, Hector, Zealous.
5. Warrior, Black Prince, Defence, Resistance.
6. Pallas, Favorite.
7. Enterprise, Research, Viper, Vixen, Waterwitch.

Added in 1870: None.

TURRET IRON-CLADS (15 IN NUMBER).

1. Devastation, Thunderer.
2. Monarch.
3. Glatton.
4. Hotspur, Rupert.
5. Royal Sovereign, Prince Albert.
6. Wyvern, Scorpion. Added in 1870.

At the dockyards: Fury, Hecate.

By contract: Cyclops, Gorgon, Hydra.

Not only in ships, however, but in officers, seamen, and guns, is the navy in a better state, at the opening of the year 1871, than it has been for years.

THE HOOSAC TUNNEL.—This wonderful bore of 5 miles through the Hoosac Mountains, goes forward with persistent steadiness, and bids fair to be an accomplished fact in 1874, as promised by the contractors, the Messrs. Shanly. Some conception of the magnitude of this great work may be formed when it is known that at the west end the workmen have fully one-third of a mile of solid mountain above their heads.

INTERCOLONIAL RAILWAY.—All the sections of this important undertaking have now been let, and it appears by an official report which has been issued, that altogether about 8,000 laborers are employed upon the work. Every effort is being made to carry on the line economically.

THE Brooklyn tower of the East River Bridge is fairly commenced on its permanent foundation. It is to be built of granite from Maine.

The caisson for the New York shore is about complete, but will not be launched probably till about the 1st of April.

A NEW depot is being built at Woodside by the Paterson and Newark Railroad Company.

CHROME STEEL.

The "Iron Age" says of the Chrome Steel Company and their works, in Brooklyn:

The Company claim that they have introduced the only great improvement in crucible steel made in many years, since by their process a perfect uniformity, a perfect homogeneousness, is insured as an absolutely certain result of their manner of working, as applied to the several grades of steel they manufacture, and especially to their high grade tool steel. They are quite certain that they can make a better steel out of a poor quality of iron than can be done by any other process; but they do use only the best kinds of steel-making iron in their manufacture. Well, in this essential, as well as in carefulness of working, they cannot claim superiority over many other steel makers, but they do show wisdom, *prima facie*, in recognizing the principle that good iron is the foundation for good steel, especially since they keep a portion of their process to themselves, and thus are exposed to attack from all other makers, as well as from the scientific fraternity. They use American iron for some kinds of steel, and, in fact, they refine some of the foreign iron before using it, while refining the steel is a part of their process, the details of which, however, they keep secret.

We saw the Norway bars cut up and charged into the crucibles, into which the powdered preparation of chrome is also introduced, they say, to the extent of 5 per cent. This chrome ore is mined near Baltimore, and contains protoxide of iron, magnesia, alumina, no silica, and, when pure, 60 per cent. of oxide of chromium. The crucibles are closed with covers and put into the melting furnaces, of which there are two, an 8-pot ordinary furnace, and a 24-pot Siemens gas furnace, which latter is a very substantially built and successfully working structure. In this the Mount Savage fire-bricks have been used, and give all satisfaction. The gas is made on double grates in a furnace situate under a separate shed in the rear of the works. The fuel used is the best Cumberland coal (Scranton), for although in these generators the poorest kind of fuel can be employed for making the gas —even sawdust, if nothing else were to be had—it has been found that the best is the cheapest. The Siemens furnace shows an economy of 50 per cent. in fuel over the old style of melting furnace in these works. The gas is led under ground into the fire-brick regenerating chambers of the furnace proper, situated to the right and left of the combustion chambers, into which the pots are set, and underneath which the furnace is open to avoid trouble in case of removal of pots, and to give access for repairs. Having valves outside of the heated portion regulate the flow of gas and air. Sturtevant blowers making 2,200 revolutions per minute, noiselessly, are used for furnishing blast to the reheating furnaces. The crucible room is covered by sectional brick arches held by clamps, and in it, by the combustion of the gas and air, an intense white heat (blue) is created, which soon melts the metal and effects the "reduction," as it is termed here. Meanwhile, the iron ingot moulds have been placed in upright position near the furnace, but below the working floor, so that their top comes about on a level with it. The workmen stand ready with bars to lift off *seriatim* the sections of the arch. One seizes and lifts out a crucible with the tongs; another knocks off the cover and skims the top of the metal with a tool which looks more like a drum-major's stick than like a dipper, while a third proceeds to the operation of refining, or whatever the operation ought to be termed, for its nature is kept secret. All one can see is that some powdered substance is carefully weighed and poured out of a cup fastened to a handle upon the top of the metal and stirred in, producing a trifling combustion and some spluttering of fiery shooting stars, with increase of light from the metal in the crucible, whereupon the contents of the pot, liquid as water, are emptied into the mould, and the crucible rolled away to cool. But all these operations do not occupy more than it takes to describe them. The crucibles used here are made in the Jersey City Crucible Works, and last three heats. Being made of graphite, the probable absorption of carbon in the metal has been recognized and carefully considered by the chemist.

The ingot very quickly sets. We eagerly examined its surface, and found that it was perfectly regular, compact, smooth, solid, without seams, or pipes, or flaw; no sinking in, or roughness, or imperfect metal to be seen on top.

When convenient, the ingots are taken hot under the hammer, and there hammered into shapes to suit further manipulations, the metal behaving as kindly as cheese, losing, however, a scale of 1 13-100 per cent., which is thrown away. The workmen say that they have not lost an ingot since the commencement. When required, the ingots or bars are reheated upon large open coke bars, served with a blast from underneath. The Company have six of Davy's direct-acting steam hammers in operation and one erecting, which work to a charm. The foundation of the anvils is well constructed, so that no shock or shaking occurs. Such blocks as are intended for slicing and rolling are reheated and rolled under chilled iron rolls into bars or rods of the usual shapes, which, if necessary, are cut into the required lengths and properly labelled for the consumer, the grades of steel having been kept altogether separate from the beginning. Other ingots are cast for forging into shapes, according to orders or patterns received from consumers. We saw fine workmanship in some cutter-heads destined to make 2,000 revolutions per minute in a large planing machine for an Eastern factory, the main portion being triangular in profile, with round smooth axle ends.

The expenditure of fuel is about 3 tons of coal to 1 ton of steel. The present capacity of production is about 1,500 tons per annum; it is contemplated, however, to erect a Martin furnace beside the crucible furnaces, which, with the additional train of rolls, would give a much larger capacity.

The Company hold that their steel is superior to anything manufactured in this country or in Europe, and back up their assertion by their willingness to prove it under any forfeiture—but, what is more to the purpose, they guarantee every pound they sell. They say that it has properties and advantages entirely its own, and is especially adapted for tools of all kinds. It can be worked at a white heat—and "cannot be injured by over heating." It can be welded to iron or to itself, leaving no trace of the weld; it can be worked and reworked without injury; and, they claim that, when made into a tool, it will do at least 50 per cent. more work than any steel, not excepting the highest priced, and be perfectly uniform in each grade, and they so warrant it, with this qualification, that it must be treated according to directions, which are mainly that it should be dipped at a low red heat, as seen in the shade; that all tools forged from a large body to a small edge should be allowed to cool off after forging, and be reheated for tempering, and they claim that the only way in which it can be spoiled is by dipping it in water or hardening mixtures when too hot. Several bars were heated to almost a white heat at our request, then worked, reheated and reworked, tempered, and a specimen cut off, of most beautiful fine grain, so hard as to cut glass, which, by the by, we showed to a well-known steel maker of Jersey City afterward, who said that if it were English steel it would not be worth anything, would be brittle as glass, but if chrome steel, it would make a tool that would "turn the hardest chilled iron roll," a compliment from a competitor. Another of the bars thus put through the white heat was split, allowed to cool, then heated again, hammered together without flux, and a chisel forged out of it, the edge being on the weld, which was tempered at very low heat, ground, and then tried on an ingot of steel, cutting out chips to half an inch deep, without showing any mark of bluntness or fracture; we took that cold chisel home as a sample. It shows the mark of having been sliced half way up the handle. As a test of toughness we were shown a $\frac{5}{8}$ in. square bar twisted cold until it looked like a cable, also a turning-lathe shaving 40 to 50 ft. long. Dynamic tests of this steel have been made by David Kirkaldy, in London, also at West Point Foundry, which latter showed as the highest strength of 12 specimens, 198,910 lbs.; lowest strength of 12 specimens, 163,760 lbs.; average of all the specimens, 179,980 lbs.; or say, 180,000 lbs. per square inch, which is $\frac{1}{3}$ more than Percy gives as the highest tensile strength attained in steel.

It is further stated that run into wire it will tie into knots, and stand 400 lbs. more in No. 16 than the wire used by hoop skirt makers; and Mr. Wood says that he

can make a tool from it to drill through Stubbs' hardest file. The tools made from this steel have been tested by Government engineers—for instance, upon the rocks at Hurl Gate—who have given very flattering certificates of its working; and from various parts of the country manufacturers have sent testimonials of its superiority for various purposes; but the most curious indirect compliment was paid it by parties who were recognized as illegitimate drillers, and, therefore, did not obtain what they wanted, *i. e.*, tools to work through a chrome iron safe.

RELATIONS OF TRAINS TO CURVES.

By S. J. WALLACE.

From "The Railroad Gazette."

Curves are requisite elements of railways, and they involve the provision of certain elements in trains. These are: Provision for keeping on the line of track, as flanges on the wheels; provision for bending the train around curves, as forming it in jointed sections; provision between the sections for the draft; and provision between the sections for resistance, as bumpers.

Draft is an element which must be extended throughout the train, reach in a vertical line from the locomotive, and must have strength equal to the strains.

The frame-work of the separate sections, or cars, may be made to serve as parts of the line of draft through the train; special parts may be provided for the purpose, and arranged in jointed parts, to which each car may be secured, leaving the car frames free from the strain.

The line of draft, whatever be its construction, should pass in a direct line from the locomotive through the train. It may pass through any portion of the cross section of the cars. But if it is not virtually in the centre line of resistance—that is, with all its joints and weak points in that line—then a strain will be thrown on one side and cause the flanges of its wheels to act against the rail with a resistance to balance the two sides. This will cause loss of power, besides the wear and tear.

On curves a simple direct line of draft cannot pass through the train. A consequent loss of power would occur on the inside rail by the strain of the engine to straighten the train, but for the composition of forces. The impetus tends to throw the train against the outside rail, in the effort to pursue a straight course. In such case, if the engine exert no new power the train will lose force against the outer rails; and if the train were stopped on the curve, the engine, in starting, would have resistance from the inner rail. On all curves this composition of the two forces takes place. If the speed of train and the exertion of engine are in right proportions to each other and the curve, the curvature of the course becomes a natural result of the united forces, without loss of power. But if the engine exert too much effort on a curve when the speed is too low, the tendency is to drag on the inner rail and to turn a short curve; and if the speed be too high with the engine too slack, the tendency is to drag the outer rail and to turn a large curve; while, if either rail drag, there is a loss of motive power.

The line of draft should be in the vertical plane of the centre of resistance in the train, on straight lines. On curves the height of the line of draft is important. If it was several feet high, too great a strain toward straightening the train on a curve might turn the cars over to the inside of the curve. But if it were in line between the two rails it would be impossible, because the rail would lie in its direct line of strain. Thus the lower the line of draft can be placed in the train, the more secure it is. This is also nearer the true line of resistance.

In passing curves with speed, heavily loaded cars will be thrown against the outer rail with force, while empty ones may be drawn against the inner rail by the force of the draft.

When the force of the engine is exerted on curves, the tendency is to throw the pair of wheels at each end of the train against the outer rail, and to draw those in the body of the train to the inner rail.

The requisite provision between the

sections of a train to resist the impact of mass motion between the cars should be at, or as near as may be to, the centre of the weight of the cars, and should act upon the main frame of the car sufficiently to communicate requisite impulse to the weight. But it is a question whether it might not be better to use a special part to communicate the action through the train, and thus free the car frame from all the strain and shock except the separate shares of each. On curves the action of such bumpers is better to be arranged to act at or toward the inner side of the train.

Car wheels have been made with conical treads to assist them in passing curves without slipping. But as it is very uncertain which rail they will be forced against, this becomes an evil, because the wear and tear of wheel and rail is increased by the greater amount of slip required when the large part of the cone is thrown on the inside rail. Besides, level tread wheels have been found to avoid the excessive rocking motion of trains, resulting from the alternate action of the cones on each side.

This partial review of the relations of trains to curves is intended merely to assist practical men to master the running of their trains, to assist engineers of construction, railway companies and inventors, in understanding the forces they have to do with, and to assist science in grasping great problems.

AN ACCOUNT OF THE REMOVAL OF SOME BROKEN PILES FROM THE BED OF THE CONNECTICUT RIVER.*

During the winter of 1868-9, the clusters of piles driven for the "Cushing Piers" of the Connecticut River Bridge, at the Shore Line Railroad crossing, were left exposed and unprotected on account of the serving of an injunction, which prevented the continuance of the work.

The up-stream cluster of Pier No. 2 had but four piles driven when the work was suspended. These stood in 37 ft. of water at low tide.

The freshet of the following spring brought down the river immense fields of thick ice, which formed a jam just above the site of the bridge.

When this gave away, it tore the platform from its place, carried away two of the four piles and broke off the other two. One was broken off just below the surface of the river bed, and the other about 2 ft. below the first. When the work was resumed in the summer of 1869, it was found necessary to remove these stumps or to change the location of the pier.

As the work on the superstructure was well advanced, it was determined to remove them.

Various methods were tried with poor success. The bed of the river is composed of a fine sand, which flowed back around the pile-heads as fast as a diver could remove it.

A curb of iron, 8 ft. in diameter, and 3 ft. high, made of three-eighth inch boiler plate, was sent down for the diver to settle around the piles, so that the heads could be cleared and a chain be passed around them, but progress was so slow, that method was abandoned and the following adopted, which proved perfectly successful.

A 4-in. gas-pipe, 5 ft. long, with a solid steel point, was placed beside the heads of the piles by the diver. Into this was inserted one end of an iron rod, long enough to reach from the bottom of the river to the reconstructed platform. On this rod was shrunk a heavy iron ring, just above the top of the gas-pipe, forming a shoulder for a hammer, sliding upon the rod, to strike upon.

By means of the hammer, which was raised by the pile-driver engine, the pipe was driven down until its top was within 2 or 3 in. of the surface of the river bed. When the tube was in place the rod was withdrawn and a charge of 4 lbs. of powder, enclosed in a tin cylinder, inserted, which was covered with the river sand and exploded by means of a battery.

Both piles were thrown out by the explosion. One was uninjured; the other was broken at about a right angle with the grain of the wood, the break extending to within about half an inch of one side.

The fracture was a perfectly clean one, none of the fibres of the wood pulling

* A Paper read before the American Society of Civil Engineers, by J. Albert Monroe, C. E., Member of the Society.

from one part to the other, and it was as clean as if the wood had been partially decayed.

These sticks were of yellow pine, 12 in. square and 12 ft. long, and were driven the November preceding.

ACCOUNT OF FLOATING DOCKS, MORE ESPECIALLY OF THOSE AT CARTAGENA AND AT FERROL.

By Mr. GEORGE BANKS RENNIE, M. Inst. C. E.

From "The Artizan."

After touching upon the various modes formerly adopted of cleaning and repairing the bottoms of ships, the author referred more particularly to the wooden floating docks introduced by Mr. Gilbert, in the United States of America, and to that made by him, in 1858, at Venice, for the Austrian Naval Arsenal of Pola, in which the two largest ships that had been docked, were the Kaiser, of 3,225 tons, and the Ferdinand Max, iron-clad, of 3,066 tons. The Messrs. Rennie, having been called upon by the Spanish Government, to make a proposition for furnishing a Floating Dock for Cartagena, capable of raising the class of iron-clad ships then about to be added to the Spanish Navy, having a weight of from 5,000 to 6,000 tons, which represented the "Numancia" and the "Vittoria" types, they proposed a dock somewhat similar to that constructed at Venice, but of iron instead of wood, with certain important modifications. In the wooden structure, in order to sink the dock sufficiently, it was not only necessary to allow water to run into the lower chambers, but water had to be forced into the top compartments at the sides, to overcome the buoyancy of the material; while in the iron structure provision had to be made to prevent the dock sinking when the lower chambers were filled with water. To accomplish this, the upper part of the side walls was divided into compartments, forming permanent air-chambers, or floats, of a capacity sufficient to maintain the decks of the side walls from 6 to 8 ft. above the water level. The author laid stress on the importance of these for the safety of iron floating docks. As an instance of the success of the Cartagena Dock, he mentioned that the Numancia, of 5,600 tons weight, had been supported on it for a period of 80 days. A list was then given of wood and iron floating docks which had come under the author's notice, all of which were of rectangular shaped sections, with the exception of the Bermuda, which was of a U section. This latter form required gates or caissons to close in the ends, which were not necessary in the rectangular section, on account of the bottom and the keel of the ship being entirely raised out of the water. Less water had also to be discharged with the rectangular form, and the amount of pumping varied as the weight of the ship, whilst in the other or U form, the smaller the ship the larger the volume of water to be discharged. The depth of the basement or lifting chamber of a floating dock, like that at Cartagena, mainly depended on the lifting power required. The thickness of the plates of the shell was $\frac{5}{8}$ in. and $1\frac{1}{4}$ in. in the centre part. For such a vessel as the Numancia, weighing 5,600 tons, the strain was estimated to be 1.32 ton per square inch, and for a vessel weighing 20 tons per lineal foot 1.5 ton per square inch.

Of the different plans of conveying docks to their destination, it was remarked that that of Pola was built at and towed from Venice, that of Havana from New Orleans, that of Alexandria from France, and the Bermuda from the Thames; while those of Cartagena, Ferrol, etc., were sent out in pieces and erected at the respective ports.

The necessary repairs, painting, or cleaning, might be performed by careening, beaching where there was sufficient rise and fall of tide, raising the submerged part out of water by pontoons, or by floating the dock into a shallow basin; this latter plan being the one adopted at Cartagena. The dock at Cartagena was 324 ft. in length, 105 ft. in breadth, and 48 ft. in height outside; these dimensions of the dock at Ferrol were 350 ft., 105 ft., and 50 ft., respectively. After giving a detailed account of the number of chambers into which the docks were divided, and the scantlings of the materials em-

ployed in their construction, the pumping machinery was described, and it was stated that it had been designed so as to be as much concentrated as possible, and thus be capable of being placed under the control of one man. The arrangement adopted was that of a pair of horizontal engines, working two pairs of lift pumps, to draw water from a common pipe, communicating with all the chambers. On the ends of these pipes were fixed the inlet sluices for filling the chambers, and on the sides smaller sluices and pipes in communication with each chamber, so that by opening all the sluices the chambers were filled, and on shutting the inlet sluices, one or any number of chambers might be discharged. Thus the whole engine power might be employed in pumping out any one compartment if it was found desirable to do so, in order to balance or level the deck. A detailed description of the engines, pumps, and sluices was then given. The shallow basin, or dock receiver, with its three lines of ways or slips, occupied the site of some old timber ponds. The basin was of a uniform depth of 16 ft. 6 in. from the top of the quay wall, and the depth of water was 12 ft. 3 in. The entrance was 126 ft. wide. The basin was 382 ft. long on the north side, and 345 ft. on the south side. The end was curved, the chord of which was 200 ft. From this end ran three lines of horizontal ways or slips, radiating to a centre. Each was 725 ft. long and 45 ft. broad, and each was laid with four lines of timber ways, intended to receive vessels after they had been raised by the floating dock. It was estimated that six vessels might be building or be under repair at the same time, besides one on the floating dock. The foundations and masonry work were then described, and it was mentioned that the caisson for closing the entrance of the basin was similar to that made by the Messrs. Rennie, for Pola. After the basin and dock were completed, water was let into the receiving basin, when the draught of water of the dock was found to be 4 ft. 7 in., giving a displacement of 4,400 tons as the weight of the dock complete. The dock was afterwards taken into the arsenal basin, and lifted vessels of various sizes—the iron-clad, Numancia being the largest. The draught of water of the dock with the Numancia was found to be 11 ft. 3 in., the dimensions of the ship being, length between the perpendiculars 316 ft., extreme beam 57 ft., and displacement at the load draught 7,420 tons. The operation in docking this and other vessels had proved the dock to be in every way efficient, and from the arrangement of the distributing valves, it could be managed with facility, either in sinking or in lifting. The *personnel* of the dock consisted of one chief engineer, one master boiler-maker, and with other assistants, amounted to eighteen men in all, and with this staff everything went on regularly and without trouble.

AMERICAN LOCOMOTIVES.*

By Mr. A. BRUNNER.

The American railroad engine, as compared with European locomotives, bears upon its face the stamp of much fertile originality, similar to that of American steamboats and bridges, when confronted with transatlantic works of a kindred class. There are differences, in the construction and working of American means of land-and-water intercourse, which may be called only *external* ones, arising from the peculiar tastes and manners of the people; but, between American engineering practice and that of the old country, there are also *principal* distinctions, called for, often, by strictly limited expenditure, by the necessity of speedy completion, and dictated in many cases by Nature herself.

It is on the American continent, where some of the grandest wonders of the world, of nature, and of art, simultaneously appear before the traveller—whether he be traversing endless prairies and the Sierra Nevada on the Pacific railroad, or skirting on a "floating palace" along the beautiful scenery of the American Rhine, the Hudson river. And probably there is no other place on the whole globe where such an impression of might and majesty is left upon the mind—no other

* This letter was originally prepared for a leading English scientific journal by a European engineer of wide experience among railroads.

spot where such a sublime scene of Eternal power and of mortal effort bursts upon the view, as at the Falls of Niagara and the Suspension bridges. It was a bold idea to stretch such a wonderful structure, as was completed by Mr. Roebling, across Niagara river, which signifies, in the symbolical language of the Iroquois Indians, "*Thunder of Waters*," streaming deep below the table land through its rocky bed, and boiling and leaping and foaming onward to the whirlpool ;—and there is also the new and graceful, 'though less monumental, Clifton bridge, suspended like iron cobweb over that tremendous ghost of spray and mist, that perpetually arises from the bright-green water in its giant leap !

Such challenges, and many other difficulties, the American engineer has met with an initiative, an amount of pluck and mechanical instinct which—as must be universally admitted—do him much individual credit, and honors the whole nation. But to return to our subject, viz.: "American locomotives." I have examined them in detail at the manufactory; witnessed their performances on all kinds of track, and I am compelled to confess, that what I saw far exceeded my anticipations.

Beginning with the engine and the various mechanical details, as designed and constructed in the manufactory, a very marked difference, as compared with English practice, will be noticed. The boiler is invariably lighter, the maximum thickness of the iron plates composing the barrel and fire-box being $\frac{3}{8}$ in. (with the exception of the tube plates, $\frac{5}{8}$ in. thick), while steel plates from $\frac{1}{4}$ in. to $\frac{5}{16}$ in. are frequently used. The boiler tubes are generally of iron. The longitudinal seams of the boiler and fire-box casing are double riveted, and they are, moreover, strengthened, in many cases, by flat bars of iron, placed sometimes across the joint at short intervals, sometimes right along the joint on the inside of the boiler. The fire-box crowns are usually stayed by transverse stays, composed of two plates $\frac{5}{8}$ in. thick, which are welded together at the ends ; these stays being connected to the crown of the fire-box casing by sling links. The fire-box casing is generally raised above the boiler barrel, the junction between the two is effected in a simple manner by the "connection sheets," forming a short conic barrel, and dispensing thus with the tedious operation of moulding the front casing plate to any intricated shape. No solid wrought-iron rings are interposed at the fire-door and fire-box bottom, but the plates are flanched so as to meet, when they are riveted together. The smoke-box is usually cylindrical, forming a continuation of the boiler barrel, and resting on a cast-iron saddle, which carries in its turn the cylinders, and, in some cases, also the bogie pin.

One of the peculiarities in American locomotive construction is the framing, which is made of square bar iron, welded together, slotted, planed all over, and entirely finished. The "bar frames," besides being very rigid in every direction, admit of easy access to the link motion; they form at the same time a good base for attaching the various brackets and guide-plates. The cylinders, which are usually outside, are hung from the top bars of the frames, in order to insure a firm base for the cylinders, and to prevent independent strains on the frames, a cast-iron separate bed-plate or "saddle" is inserted between them, or the cylinder castings are made to extend inwards, where they are firmly bolted together. The valve-chests are on the top of the cylinders—a very good plan, by the by—the valves receiving their reciprocal motion, through the intervention of rocking shafts, from the eccentrics and motion links, which are placed, as in English engines inside the frames.

As a rule, the various details of the motion and gearing are admirably well proportioned and carried out, although, for the sake of cheapness, "professional etiquette" is sometimes grossly neglected, as witness cast-iron piston-rod crossheads, cast in one piece with the pin and guide-blocks! The ends of the connecting and coupling-rods, where they take hold of the crank-pins, are always fitted with straps, secured similarly to the large ends of connecting-rods for inside cylinder engines. The brasses are generally closed on the outside, so that the crank-pins may be entirely enveloped, and by this "dodge" (which is well worthy of imitation) the pins are kept out of the way of dirt. An attempt is often made to guide the piston-rod crossheads by bars, arranged *above* the centre-line of the cylinders. Sometimes a single guide-bar only is employed, care being taken, however, to give it the necessary rigidity, and to pro-

vide ample bearing surfaces for the upward thrust and the downward pull of the connecting-rod. The object of this arrangement, which is identical with the plans of Mr. Stroudley and of Mr. Reynolds, is to clear the bogie wheels, or to effect, in the case of an engine with the leading wheels coupled, a reduction of the distance at which the cylinders are apart transversely.

The cast-iron wheels form another distinctive feature in American practice. The small chilled cast-iron disc wheels of their engine-tender and car trucks answer admirably well, being cheap, strong, and durable at the same time; but, as regards the driving wheels with hollow spokes and rim, they are, after all, but a primitive contrivance as compared with the solid wrought-iron wheels now manufactured to such perfection by the leading British locomotive makers, and especially by some Belgian and French firms. To turn out a really good wrought-iron wheel, special tools and appliances, and superior manual skill, are indispensable, and it is, perhaps, the lack of these that has prevented the Americans from making an attempt in this direction.

The boiler feed-pumps also deserve mention, injectors being totally ignored, or, if employed at all, of such dimensions as to serve merely as auxiliary boiler-feeders. The pumps are always placed on the outside of the frames, and frequently even outside the coupling-rods, in which latter case they are bolted on the guide-bar brackets, being thus of very easy access. The pumps are usually worked from the piston-rod crossheads, and they are provided with 2 air-chambers, 1 for the suction and 1 for the delivery-pipe.

Much ingenuity is displayed in the manner of setting engine and tender on the wheels; in fact, the problem of making an easy riding engine, offering, at the same time, the least amount of internal resistance, has been solved by the Americans most successfully. Much might be written on the history of the swivelling-truck, the faithful "track-feeler" of the American locomotive, and it would take a very graphic pen, indeed, to record fully all the modifications and transformations this useful contrivance has already encountered. Swivelling-trucks — better known, perhaps, by the quasi-mysterious name of "Bogies"—are employed as carriers under the engines, tenders, and cars on all American railways, but, as far as I could learn, no attempt has ever been made to utilize the advantages of the bogie system in that part of the engine, which, properly speaking, supplies the traction power; in other words, the steam-cylinders and gearings are always fitted to the main system of the engine, independently of the bogies. If the trucks, as they roll along, are watched from the car-platforms, it will be noticed that they get the more uneasy the more the speed increases, manifesting, at high speeds, a strong, "galloping" movement; and this characteristic phenomenon would, perhaps, be seriouly aggravated by the additional disturbing forces resulting from the employment of steam-cylinders. At all events, the check-chains provided throughout, in connection with the American trucks, are not suggestive of abundant safety. For heavy work, at very low speeds, however, such as climbing crooked inclines, it would be advisable to employ engines mounted upon 2 steam-trucks, whereby both the power and the flexibility of the locomotive would be increased. Compensating levers are used on all American engines, not only between the coupled driving-wheels, but often, also, between the front pair of coupled wheels and the bogie. In many cases the equalization of the weight is still further carried out by the employment of transverse compensating beams, as used also by Borsig, and on almost all the German locomotives.

As regards the general form of American locomotives, the most striking feature is the extent to which the weight is subdivided over a greater number of wheels. The standard passenger engine has invariably 4 coupled driving wheels, 1 four-wheeled truck under the forward part of the locomotive, and 2 four-wheeled trucks under the tender, making in all 16 wheels against the 10 or 11 wheels of an English engine of similar proportions. On some lines, the goods traffic is worked by exactly the same type of engine, the increased traction power being obtained merely by a slightly reduced diameter of the driving wheels, and a few tons more adhesion. But, what may be termed the "standard" goods engine, has generally 6 coupled driving wheels of from 4 ft. 3 in. to 4 ft. 8 in. in diameter, while the driving wheels

of the passenger engine range from 5 ft. to 5 ft. 8 in. in diameter. The weight of the passenger locomotives, loaded, is from 27 to 30 tons, of which weight 60 to 65 per cent. rests on the coupled wheels. The weight per driving wheel on the goods engine is very seldom more, but having usually 2 coupled wheels more, the adhesive power of the goods engine would consequently be 50 per cent. greater than that of the passenger engine.

In outside appearance and finish the American locomotives present much original conception and, not unfrequently, real artistic merit. The Yankees seem to place great pride in their engines; and it is indeed a proud sight to see an American engine entering a station, blazing in polished brass, embellished with rich peinture, bells ringing and whistle roaring—a sight very apt to compensate, temporary for the noted shortcomings of American stations. At a first glance, some of the accessories, that give so much individuality to the engine, as cow-catchers, signal bells, tremendous head-lights and mighty steam-whistles, may appear somewhat superfluous; but this idea is soon dispelled when a journey is made on the engine foot-plate. It will then be observed that there is nobody to keep the track; at way crossings there is no barrier of any kind, but a board is stuck up instead, bearing one of the following warning descriptions: Railway crossing! Look out for the engine! or, as here in Lower Canada: Traversée de chemin de fer! The well-known voluminous smoke-stacks are necessary on account of some kinds of fuel consumed, while the commodious "cabs" shelter the men, through summer and winter, in the performance of their arduous duties. We will now proceed to witness the performance of American engines. One of the most striking observations is the ease, not to say "grace," with which the comparatively light locomotives do their work—and heavy work, too—over the rough roads of the United States and Canada. Mr. Eugène Flachat is evidently of opinion that the engines are worked at the sacrifice of regularity, speed, and security, for, on page 229 in his "Traversée des Alpes," he says:—

"The American locomotives are not constructed on a system that gives them a superior power to that of other engines; they are used on the inclines to the maximum of their power and adhesion. This produces an irregularity in their running which would not be admissible with the great number of trains on our lines, nor with safety, which is the matter of first importance in this mode of travelling. The American engine and train is to be compared to a ship crossing the ocean. She sails fast when everything is favorable; she goes slowly when the work is increased by the variation of the profile; she overcomes great inclines by reducing her speed considerably, without the machine being endowed with any superiority as to the production of steam, or to the means of transmitting the motive power of the cylinders to the wheels."

The average gross tonnage of passenger trains here is probably double that of English trains; still, with from 6 to 7 passenger cars, weighing, loaded, about 20 tons each, a baggage-car of the same weight, and a Pullman drawing-room or sleeping-car of from 30 to 35 tons weight, the engine gets quickly away from the stations, and without "slipping." Of course there must be some material reason to account for the superior useful effect given by American engines. In the first place, American engineers generally take the car friction at 5 lbs., and the engine friction at 10 lbs. per ton, irrespective of atmospheric resistances. These low figures—accepted, probably, more by long experience than by any direct experiments upon train resistances—must be attributed chiefly to the employment of bogie rolling-stock, central buffers with loose couplings and oil-tight axle-boxes, which latter are always lined with an excellent bearing alloy. I have had some conversation, on the subject of locomotive performances, with one of the leading railway engineers in the States, and although the theories then advanced may not universally be accepted as infallible, yet they carry such weight with them that it will be well to enumerate them here. These points, which are independent of train resistances, refer essentially to the great steaming power of American locomotive boilers, and to the manner in which these boilers are being worked and fed. The quick steam-generation is mainly due to three causes, viz.: the intensity of the fire, the thinness of the plates composing the fire-box, and the extremely forced draught.

By these means a boiler of moderate proportions and heating surface is worked up—though at a more rapid rate of combustion—to an extent never attempted abroad. The injector has been condemned by the Americans as being an expensive boiler-feeder. Counter pressure steam-brakes are equally unpopular out here, but each swivelling truck under the train, with the exception of the leading engine bogie, is always furnished with a hand-brake.

Great activity prevails in American railway matters, and all the locomotive works are consequently very busy. I understand that Messrs. Baldwin, of Philadelphia, will have turned out not less than 200 locomotives during the last 12 months. Locomotive building on this continent must, indeed, have made great progress of late, as verified by the perfect organization of the workshops and the systematical manner in which the work is turned out. In general, my visit to this great country has made a lively impression on me, which, I am sure, will be shared by most impartial critics, that in the specialty of locomotive construction the Americans are fully equal, if not ahead of the best European practice.

SEWAGE CROPS.

From "The Engineer."

Every candid and impartial person will admit that the question of the utilization of sewage upon the principle of irrigation has successfully passed through the preliminary stages. The first steps, so difficult to achieve, have been gained. The advocates of this system, which we were the first to uphold and maintain, have, after a hard fight, discomfited their enemies, vanquished the violent opposition they experienced for so long a time, and established the truth and soundness of the principle to the satisfaction of the Government, of local boards, and of private individuals. There are still, undoubtedly, a few who refuse to believe in the facts placed before them, and, with that invincible obstinacy which some of the human race possess in common with the lower animals, deny the accuracy and impeach the veracity of results that carry the fullest conviction to the minds of the dispassionate and disinterested. As the present year will probably prove an eventful one for the sewage problem, let us briefly review the claims it has to the consideration of the sanitary engineer, and those authorities whose especial duty it is to provide for the removal and disposal of the sewage of our towns and villages. It has been demonstrated that sewage can be applied with profit, agriculturally and financially, to nearly every description of plant and crop that is grown in our climate for the use and convenience of man. Respecting the kind of crop upon which it can be utilized most effectively, we shall have a word to say hereafter. One of the principal points to establish in a conclusive manner was, that this beneficial result could be obtained without creating a nuisance. Many who acknowledged the value of sewage as a fertilizing medium, were yet of opinion that its utilization in practice would be attended with so much annoyance to the neighborhood, as to give rise to legal proceedings which wouldt erminate in the granting of an injunction against the prosecution of the undertaking. In a very few instances, notably near Kingston, and at Bromley, Kent, the opposition of landed proprietors was sufficient to stop the measures that ought to have been carried out for the welfare of the inhabitants. But the evidence of several years' residence by laborers and their families on sewage farms, and in their immediate vicinity, is a proof that there is nothing in connection with works of this description injurious to health. The mere presence, during extremely hot weather, of any slight effluvia from the carriers or channels which distribute the liquid over the farm is of little or no moment. An odorless manure is of very little value, as every farmer will assert. We have walked over numerous sewage farms, and never experienced anything approaching the smell that proceeds from fields newly manured with ordinary farm-yard manure. There is nothing more intolerable at certain seasons of the year than the smell of flax-fields, but we never heard of its being productive of any ill-effects upon

the people dwelling near. Although in a sanitary point of view there may be no evil to be anticipated from the proximity of a sewage-farm to a populated district, yet the recommendation is no doubt a wise one which advises that land appropriated to the purpose of the utilization of sewage by irrigation, should not be situated at a less distance than one mile from a town.

Besides the utilization of sewage as a fertilizer for the land, there is another feature belonging to the problem which is equally, if not more, important. It is the disinfecting and deodorization of the sewage. After extracting the valuable manurial ingredients from the highly diluted fluid mass, there remains a very large quantity of liquid which is of no further use. Nevertheless it is necessary that it be disposed of in some way or another, and the readiest means of getting rid of it was simply to allow it to flow into the nearest natural wtercourse. This was the very plan that was first adopted in disposing of the raw sewage, and one which the whole system of irrigation is intended to prevent. Nevetheless, if the effluent water, as it it termed, or the liquid remaining after the utilization of the sewage had been accomplished, could be purified to a sufficient degree, it might then be permitted to be discharged into the adjoining river or stream. It became, therefore, incumbent upon the advocates of the irrigation principle to demonstrate that, after passing over the land, the effluent water was free from all offensive and deleterious particles, and might be turned into a stream without polluting its contents. This point was in truth more essential than the other, for as injunctions were granted against local boards and other offending parties for fouling rivers and streams, the first step was to avoid this in future. It must be borne in mind that there was not, nor is not, any obligation, legal or otherwise, to utilize sewage in any manner whatever. The obligation is to keep it from polluting the natural watercourses of the country, and irrigation, or any other mode of treatment, is only a means to the end. As the course of action local boards and sewer authorities have recently found themselves compelled to adopt, entails a considerable expenditure, the object sought is to select such a method of dealing with the sewage as will afford some return for the large outlay incurred. Hence it is that these gentlemen gave such large credence to the various disinfecting and deodorizing schemes put forward with so much effrontery. These modes of treatment were all exceedingly specious in character. They offered the perplexed and embarrased local boards a speedy extraction from all their difficulties, with the prospect of a large percentage by way of return in the first cost of the necessary works. The rest is known. The sewer authorities fell into the snare, and, after mulcting the unfortunate ratepayers, have been ultimately obliged to abandon all such vain projects, and betake themselves to the only true principle, viz, that of irrigation. Returning to the pollution of streams by the effluent water, the results at Croydon proved that after passing over the land, the liquid only added two grains of solid matter per gallon to the contents of the stream into which it was allowed to flow. Upon this rock all the deodorizing schemes have split. Granting that a very few of them can turn out a salable manure, which is very doubtful, not one of them can so purify the effluent water that it may pass into a river. So that, supposing they acomplish the first portion of the task, they altogether fail in the second. On the other hand, the utilization of sewage by irrigation accomplishes both. It utilizes the sewage, and purifies it at one and the same operation. It requires no chemical agents, no blood, bone, or charcoal. The agents it uses are those supplied by the growing plants themselves, which assimilate for their own benefit the manurial ingredients in the sewage, strain it, as it were, of its offensive properties, and, thus cleansed and purified, it may with perfect impunity be permitted to mingle with the waters of the nearest stream.

Having surmounted all preliminary obstacles, and grown crops in luxuriant abundance by the application of sewage to land, the question that now presents itself for solution is, which are the best paying crops to raise from sewage? It must not be understood from this that the best paying crop will be necessarily that which is produced most abundantly from land irrigated with sewage. Local circumstances, and the general character of the markets prevailing in the districts, will determine the crop which will yield

the greatest return. For instance, in a district where horse labor is exclusively employed, it would probably pay the farmer better to lay out his fields in grass than to sow them with cereals, notwithstanding the relatively higher value per acre of the latter. Thus the real paying value of a crop is no criterion of its powers of benefiting by the application of sewage. It is not our intention to discuss the particular influence exercised by local contingencies on the commercial value of sewage-grown crops, but to draw attention to the manner in which they are severally affected by its application, supposing other circumstances to be in common. For it is easily perceived that, owing to exceptional events, a perfectly factitious price might be given for any one particular crop, but at the same time this would not be a fair estimate of the effect of sewage upon it in comparison with other productions. It may also be fairly urged that in striking a balance the nature of the soil ought to be regarded, since one of the greatest advantages attendant upon irrigation with sewage is that it enables crops to be raised upon land which has generally been considered hopelessly sterile. It is a far greater triumph to grow a crop worth £20 per acre upon land which formerly produced nothing but weeds, than to raise a crop worth £30 per acre upon land which formerly yielded produce worth £20. There are, no doubt, some descriptions of soil which are so fertile as to yield a comparatively very poor return for the expense incurred in irrigating them with sewage. In a word, they do not require any manure. As a rule, the poorest kinds of soil which ordinary farming can do nothing with are the very ones to which to apply sewage, for two reasons. One is that they are otherwise totally unproductive, and the other that they will "stand," to use a common term, almost any amount of it, provided they be sown with rye grass. This is a point that local boards, and all who have to provide for the continuous disposal of large quantities of sewage, cannot lose sight of. Whatever crops may be selected, there must be a certain acreage appropriated to grass, in order that the remainder of the farm may not be injured by over or unseasonable doses. The too frequent repetition of a stimulant invariably does more harm than good, and defeats the very purpose it is intended to accomplish.

Taking into consideration only the acreage and the money actually paid for the produce of the ground, the highest price has been obtained by strawberries. They have been so fine in quality as to gain a prize at the Royal Horticultural Exhibition, and fetched the astonishing sum of £75 per acre. Strawberries pertain rather to the province of market gardeners than to that of farmers, but the example conclusively points out the almost universal scope of the irrigation principle. On the Romford farm, which constitutes the first instance of individual enterprise in connection with the sewage problem, onions have reached the price of £48 per acre. There is, however, a disadvantage connected with both these, as well as with some other descriptions of plants. They are rather precarious. Obviously it is better to select a plant or crop that is certain to yield a fair average annual produce than to put in the ground one which may give a very high return one season, and a very low one, or perhaps none at all, the next. As an example of "quick returns," spinach may be quoted, for some was sown, cut 29 days afterwards, and sold for £22 the acre. But as a counterbalance, another lot, sown subsequently, proved a failure, and was given to the cattle. If we were inclined to give the preference to any particular plants, we should select cabbages and mangold wurzel as likely to yield a good constant annual average. They are both of them certain of a sale, and are, besides, hardy, and not liable to be affected by contingencies that might prove detrimental to others of a more delicate organization. The difference between selling a crop on the ground and in the market is well exemplified in the case of some carrots grown on the Romford farm.

A portion of the produce was sold for £20 on the ground, and the remainder in the market brought £40 per acre. Against this latter price must be set the cost of carriage, which is frequently very high. It will be found generally to be preferable to sell the crop on the ground, instead of incurring the expense and risk of taking it to market, and this plan is the favorite with both seller and purchaser. While there is no doubt of the

success that has attended the application of sewage to oats, maize, wheat, and other cereals, there is a manifest tendency in sewage farming on the whole to cultivate green crops. They, in fact, yield the quickest return for the capital expended, and therefore it is but natural they should receive the greatest amount of attention on the part of the agriculturist. Moreover there is another reason for their adoption. The land appropriated to them does not require so expensive a method of laying out as in the case of cereals. The latter will demand considerable more care and science than have hitherto been bestowed upon them, before the proper treatment of them with sewage is thoroughly understood. They will not take the quantity that green and root crops will, and the periods of application must be regulated with a far greater degree of nicety.

LOCOMOTIVES vs. PORTABLE ENGINES.

From "Engineering."

Although during the past ten or fifteen years locomotive construction has made steady progress, and although much has been done to render locomotives more durable and better capable of dealing with the heavy work they have now a days to perform, yet we fear that, regarded purely and simply as steam users, they cannot be said to have undergone any material improvement. The use of steel for tyres, and many working parts, the adoption of larger bearing surfaces, and the use of improved means of lubrication, have lessened the cost of maintenance; the increased employment of the bogie in its various forms, and of appliances for giving the terminal wheels lateral play, have rendered engines better adapted for traversing curves, and have reduced wear and tear; and, lastly, the use of higher pressures of steam has enabled the power of engines to be increased, and has been attended with other beneficial results; but none of these improvements, important although they undoubtedly are, can be said to affect the statement which we have just made. It is true that by the employment of higher pressures of steam, locomotives have been probably enabled to develop a greater amount of work per pound of fuel burnt; but this is simply due to the increase of pressure *per se*, and can scarcely be said to be the result of the steam being more efficiently utilized after it leaves the boiler. It is not long since it was the fashion to advise portable engine builders to pay more attention to what has been done by locomotive engineers, but although this advice may still be given with regard to many matters of constructive detail, yet we fear that as far as the use of steam is concerned the advice will have to be reversed, and locomotive engineers will have to pay more attention to the practice of makers of portable engines. It may appear rank heresy to speak in this way; but the statement is, nevertheless, one well supported by facts. We do not mean to affirm that a common portable engine is a more economical steam user than an ordinary locomotive engine, but we assert that portable engines of the better class, such as are now sold by the leading makers to all who will pay for them, are, when the pressure of steam at which they are worked is taken into consideration, far more economical steam users than the best locomotives now in use. In other words, if the locomotive and the high-class portable engine were worked at the same steam pressure the latter would give out a considerably greater amount of work per pound of fuel consumed, than the former.

Stripped of its wheels and special appliances for enabling it to travel on rails and draw trains behind it, a locomotive is simply a non-condensing engine with unjacketed cylinders placed below the boiler level, and with the distribution of the steam effected by a common slide valve; and every portable engine builder of experience well knows that if he was to enter into a competitive trial with such an engine, he would be simply "nowhere." The experience of such trials has shown clearly the benefits derivable from the use of steam-jacketed cylinders, of separate expansion slides, and of arrangements for supplying the cylinder with steam in a perfectly dry state, and the teachings of such experience are now never

neglected by the leading makers of portable engines. Up to the present time the high pressures of steam used in locomotives, and the high piston speeds at which such engines are worked, have enabled them to hold their own; but as these sources of economy are gradually being incorporated in portable engine practice, locomotives will, we fear, be left behind unless something be done to improve them.

One of the first points which should, we think, be attended to, is the adoption of arrangements for insuring a supply of dry steam to the cylinders. There are, we know, many locomotive boilers which prime very little; but there are few which furnish steam in that thoroughly dry state in which it is so desirable to obtain it. In portable engines where the cylinders are situated on the top of the boiler, the carrying over of water with the steam is more easily prevented than when, as is the case with a locomotive, the cylinders are at a lower level; but inasmuch as in the latter instance the relative positions of the cylinders and boiler cannot be altered, special means must be resorted to for obtaining dry steam. Three methods of securing this dryness may be enumerated, thus: 1. The steam may be superheated on its way from the boiler to the cylinders; 2. The boiler may be worked at a higher pressure than would otherwise be employed, and the drying process may be effected by wire drawing; and 3. Mechanical means may be employed for separating the steam and water, and preventing the latter from entering the cylinder. The first of these plans—that of superheating the steam—has been tried on locomotives with but very indifferent practical success; and, indeed, the temperature of the high pressure steam now used can scarcely be much increased without giving rise to difficulties with the packing of the glands and lubrication of valves and pistons. The second plan is one which is often adopted unintentionally and it is no doubt effective within certain limits; but it can scarcely be said to be one worthy of extensive adoption. There thus remains the third plan, of mechanical separation, and this we believe, if properly worked out, will effect the desired results. It has long been known, that if a current of steam carrying water in suspension be suddenly diverted from its course, the momentum of the water will cause the latter to be carried forward in the direction in which the steam was moving before diversion; and if proper arrangements be employed, it can thus be collected and drawn off from the steam. "Separators" constructed on this principle have long been used by marine engineers and by some stationary engine builders with great success, and we believe their use on locomotive engines would be attended with excellent results. We may state here, that there is nothing new in this proposal to use separators on locomotives. More than twenty years ago, a separator, acting on the principle we have mentioned, was applied to the mouth of the steam pipe of a French locomotive by Mr. Edwards, and arrangements of a similar kind in modified forms have been since employed by other locomotive engineers. So far as we are aware, however, separators have only been applied to locomotives with a view of preventing the direct entrance of water into the steam pipe, and not with a view of further drying the steam on its way to the cylinders. The application of a separator to the mouth of a steam pipe, as was done by Edwards, is no doubt an excellent plan —far better, we believe, than any arrangement of screens and baffle plates—but in addition to this a second separator could be advantageously applied to the steam pipe just on entering the steam chest, or if this could not be conveniently done, fixed outside the smoke-box tube plate in place of the usual T-piece. The latter situation possesses the advantage, also, that any water collected in the separator could be allowed to run back direct to the boiler, while in the case of a separator placed at a lower level special arrangements would have to be provided for the discharge of this water. Separators, if properly constructed, offer no appreciable resistance to the flow of steam, and their cost is so insignificant that it is difficult to see any objection to their extensive use.

The next point — after getting dry steam to the cylinders—is to prevent condensation from taking place in the cylinders themselves during expansion. Superheating not being available, the only effective way of doing this is by employing steam jackets. Careful cleading of the cylinders and covers will, no doubt, do much; but no amount of cleading will

effectively replace a steam jacket even in non-condensing engines working with a moderate degree of expansion, and this fact the practice of portable engine makers has long proved decisively. In inside-cylinder locomotives the tops of the cylinder are to a certain extent kept hot by the hot gases in the smoke-box, but the dust and ashes which collect at the bottom of the latter soon form a non-conducting coating, through which but a slight transmission of heat to the cylinders can take place. In some outside cylinder engines, also, the hot gases have access to the outer surface of the barrels of the cylinders; but the arrangement is rarely such that any free circulation of the gases can take place, and thus the effect is, that those particles in immediate contact with the cylinders become cooled, and the latter merely become surrounded by jackets containing gases at a temperature far below that existing in the main body of the smoke-box. The latter temperature is in fact so high that if currents of the hot gases were made to circulate freely round the cylinders the effect would be to carbonize all the lubricating materials, and cause the destruction of the rubbing surfaces. The application of a practically effective air jacket—or rather gas jacket—to the cylinders being impossible, and superheating being unavailable, it follows, as we have said, that recourse must be had to steam jacketing if we desire to prevent condensation from taking place in the cylinders during expansion.

The principal objections which have been urged to the application of steam jackets to the cylinders of locomotives are: 1st, that in the case of inside cylinder engines there is rarely room for such jackets; and 2d, that in the case of outside cylinder engines the employment of steam jackets would increase the weight at a point where in many cases an excess of weight already exists. The first of these objections is to a certain extent unanswerable, and there are no doubt many instances in which inside cylinders could only be jacketed over but a small proportion of their surfaces—so small, in fact, as not to make it worth while to apply jackets at all. In the case of oustide-cylinder engines, however, the objection which has been raised is, we think, of but little importance. Portable engine builders now very generally cast their cylinders and steam jackets in one piece, and there is no reason why the same thing should not be done with the locomotive cylinders. Under these circumstances the addition of a steam jacket to a 16-in. cylinder of a length suitable for 2 ft. stroke should not increase the weight of the casting more than about $2\frac{1}{4}$ cwt. In the case of bogie engines having the leading wheels well forward, such an increase of weight would, of course, be of no importance; while in the case of engines having considerable overhang at the front end still lighter steam jackets might be formed by inserting a steel bush, say $\frac{1}{4}$ in. thick in each cylinder, the cylinder casting being chambered out around the bush to form the jacket. Steel linings or bushes have been applied to cylinders in this way by at least one firm of portable engine builders, and they have been found to wear exceedingly well.

In whatever way the steam jackets are formed, however, it is essential that they should be supplied with steam at the full boiler pressure, and that they should be kept clear of air and of the water arising from condensation; and it is in the fulfilment of these latter conditions that the chief practical difficulty of applying steam jackets to locomotive cylinders appears to us to consist. It being supposed that the steam jackets are completely distinct from the valve chests, a small pipe led to each direct from the boiler would, of course, serve to keep them supplied with steam at the full pressure; but to get effectively rid of the water arising from condensation is a more difficult affair. It would, of course, be easy to fit the jackets with blow-off cocks to be opened occasionally by hand; but such an arrangement would have the defect of being dependent for its efficiency upon the attention of the driver or fireman, and this we fear could scarcely be trusted for such a matter. A self-acting steam, or rather water, trap would no doubt serve the desired purpose better if it could be depended upon, and probably some form of steam trap now in use could be made available for the purpose, care being taken that the hot water blown off is delivered into the tanks. Probably the best plan, however, would be to allow the water from the jackets to drain down into a small tank, and to place either in this tank or in immediate connection with it, a small pump kept continually at work so as to return the water at once into the

boiler. This pump would, of course, have the full boiler pressure on both the suction and delivery side, and the work it would have to do therefore would merely be to lift the water from the collecting tank level into the boiler.

The question will probably be asked by some locomotive engineers, whether the additional economy obtainable by the employment of steam jackets is such as to warrant even the slight additional cost and complication which the use of such jackets involve? To this question a reply in the affirmative may in most cases be unhesitatingly given. Of course there are some locomotives employed on duty which necessitates their being almost always worked nearly in full gear, and under such circumstances the use of steam jackets would effect but very little saving. In all cases where engines are employed on work permitting them to be run with the steam cut off even as late as two-fifths of the stroke, however, the employment of steam jackets will be found to result in a marked advantage; and, in fact, if the arrangements are properly carried out, a saving of some 8 or 10 per cent. in the steam used while working expansively may be depended upon. In countries where fuel is dear, such a saving would be of especial importance.

We have now touched upon two points in which locomotive practice is open to improvement, and there are a few others connected with the use of the steam in such engines of which we also intended to speak here. The present article has, however, extended to such a length that we must postpone our further remarks until a future number. We shall, however, take an early opportunity of returning to the subject and directing attention to the points to which we have referred.

MOVABLE BRIDGES.

From "The Mechanics' Magazine."

The majority of bridges have a double duty to fulfil. It is not sufficient that they allow of the passage of loads over them, but they must also provide for their transit underneath. If a railway bridge crosses a road, it must do so in such a manner that its soffit shall be at such an elevation as will permit of the ordinary traffic being unimpeded. The same consideration must be attended to in the case of bridging a navigable river or stream. While, on the one hand, the primary object of the structure is to establish an uninterrupted communication from the one bank to the other, the necessity of maintaining open a certain amount of waterway for the passage of boats and vessels of the usual tonnage, is equally imperative. It is, in fact, a question of double headway. There must be in every instance of the nature referred to a minimum rise of the bridge above the water to accommodate the navigation. This quantity may vary between almost any limits, according to the particular exigencies of different localities. It may be as much as 100 ft., as in the case of the Britannia Bridge over the Menai Straits, or it may be only a few feet, and thus just allow a small rowing boat to pass beneath. Again, while this provision is unavoidable, it must not interfere with the level of the adjacent shores or banks. Should the minimum rise of the bridge necessary to preserve the traffic below be so great as to exceed a certain height above the level of the bank, the erection of the structure may become financially or constructively impracticable. In order to rise from the banks to the centre of the bridge the gradients might be so steep as to virtually forbid the work. Or, in order to reduce them to a practical slope, it might be necessary to build retaining walls and embankments of so heavy and expensive a description as to prove fatal to the entertainment of the project. Under these circumstances, when, for one or more of the reasons given above, it becomes impossible to adjust the heading or rise of the bridge so as to suit both descriptions of traffic, that is, above and below, another design of bridge must be adopted, differing in some particulars from those in general employment. Instead of being permanently fixed to their supports or abutments, they have free motion around one or more of them. Dividing all bridges into the two divisions of fixed and movable, it is under this

latter term we must include those we are about to draw attention to.

Movable bridges may therefore be considered to comprise all those which temporarily change their position in order to allow of the passage of one or other of the two descriptions of traffic they are designed to accommodate. The earliest specimens of movable bridges are probably to be found in the old drawbridge—the rude engineering appliance used in feudal and earlier times to open or cut off as might be desirable communication with the castle and the stronghold. There is, however, another description of bridge to which the same name is attached, which we shall refer to as we proceed. Under the general term "movable" may therefore be classed draw, swing, and swivel bridges. These subsidiary terms are frequently applied somewhat indiscriminately, but they nevertheless possess some distinctive features, and, as an example, a swivel bridge is generally one that swivels or slues round on a centre pier or support, and when closed spans two openings. But the same term, although perhaps with less propriety, may be applied to the case of one span, in which the whole bridge consists of two semi-arches meeting at the centre, each of which slues round on its own independent support. This represents the simplest case, which we will first draw attention to. It consists of one opening, and it is proposed to span it by a movable bridge which shall be composed of two pieces meeting at the centre, each of which can be moved on its support until it lies in a recess and will thus leave the opening perfectly free for the passage of the traffic underneath. Whatever principle may be adopted in the design, whether the arch or the horizontal girder, the first point to be borne in mind is that the one half is not supposed theoretically to receive any assistance from the other. Each half must be designed and constructed to carry its own share of the load without any reference to the other. The bridge consists, in fact, of a pair of cantilevers, which are sometimes in contact at their free extremities and sometimes separated. Unless the opening be of very insignificant dimensions, or to be necessary to maintain a uniform heading along the whole soffit, the most economical principle to adopt is that of the arch. Each half of the bridge will in that case be composed of a semi-arched cantilever, the proportions of the relative parts of which will vary according to the size of the span. The design we should select in these instances would be that of a wrought-iron braced semi-arch, and the following cursory analysis of the strains upon it will demonstrate that that material is the best adapted for the purpose. Regarding each half of the bridge as a cantilever, the strains will increase gradually from the centre, where they are very small, to the end, where they reach a maximum. But this arrangement varies with the relation of the separate parts of the design. At present it is considered to consist of an upper and lower flange, connected at suitable intervals by web of open lattice work composed of bars inclined at various angles to the horizon. The upper flange is horizontal and the lower curved. The radius of the latter will depend upon the width of the opening and the rise of the arch. It may almost be said to depend upon the former of these dimensions alone, since the rise is always a function of the span. The strains upon the upper flange are tensile in character, and, as already stated, accumulate in intensity from the centre to the support. Upon the lower flange the strains are compressive, increasing in amount in the same direction. Towards the end of the arch, these strains upon the two flanges are practically equal, but not so at the centre. The strains upon the bars in the web are compressive and tensile according to their position and angle of inclination, and are a maximum at the centre and a minimum at the abutment. Owing to the continually changing angle of inclination of the bars, there is no general rule for determining which of them are struts and which ties. This distinction must be made for each individual case in question. Were it not for the fact that the upper flange undergoes strains of tension, it would perhaps be more economical to use cast instead of wrought iron as the material for the bridge. But, apart from this consideration, the treacherous nature of cast iron renders it unreliable in instances where it is subjected to any vibratory or concussive action.

If instead of one opening there are two, with a pier in the centre of the water-

way, the same principle of design is equally applicable, but there will be a gain in economy, as can readily be shown. In the example of a single opening, it is necessary to prolong such semi-arch backwards, so to speak, on the abutments, and to load it with a heavy weight to counterpoise that of the cantilever. The part of the arch which is thus prolonged over the bearings is usually made with both flanges parallel, and constitutes a kind of small box, in which the counterpoise is placed. When there are two openings, and two of the cantilevers are connected together over the central pier, around which they swivel, they balance one another, and the counterweight can be dispensed with. Precaution must be taken to allow sufficient bearing over the central support, for it would not do to rely upon the theoretical balance of the two cantilevers. There must be some margin left, so that the equilibrium is not likely to be upset by any sudden impulse imparted to one of the projecting halves while the whole may be in motion. The machinery necessary for moving the bridge may be controlled by steam, hydraulic, or hand power, and will manifestly depend upon the scale upon which the design is constructed. As a rule, hand power is that oftenest employed. This follows from the circumstance that these descriptions of bridges are mostly used for establishing communication across the entrances to docks and basins, in which cases the openings are seldom more than 60 ft. or 70 ft. in width. If the bridge be designed on the plan already described, the half could be moved with facility by means of an ordinary winch. It is not our intention to enter into the details of the mechanical appliance required in particular instances, the more especially as there is no difficulty in effecting an arrangement which shall accomplish all that is needed. There are only two conditions to be fulfilled, but these must be carried out most thoroughly. One is, that the motion should be produced with ease, and the other with certainty. A bridge that "sticks" when it ought to open is a perpetual nuisance to all those who are in any way dependent upon its working properly. In that situation, it is alike useless to both parties, as it will accommodate neither the upper nor the lower traffic. We have known very serious delays to occur owing to the difficulty of getting a bridge to open when required.

There is another case of movable bridge to be considered, which is of a more expensive character than that described. It is that in which the whole bridge has to be moved from one support, and in which the horizontal girder is the principle of design adopted. When the moving is effected in a similar manner to that of the former example, this is merely an extension of the case, bearing in mind that the horizontal girder is substituted for the semi-arch. The length of the cantilever is doubled, on the supposition that the spans of both openings are equal, and a corresponding increase of weight to be moved and counterpoised takes place. It is almost an engineering axiom that, neglecting the foundations, or, what amounts to the same, supposing them to be favorable, it is invariably cheaper to build a bridge of two small spans than of one large one. Similarly, it will always be far more economical to construct a movable bridge in two separate halves than to make it in one entire span. This argument applies more forcibly in the case of movable bridges than of fixed, inasmuch as the former are really cantilevers, and not girders supported at both extremities. It is true that when a swing bridge which is entire throughout its whole span is brought to its bearings, it is then no doubt in the position of a girder supported at both ends. But at other times, when it is lifted off one of its supports and is put into motion, it is, so far as its own weight is concerned, a perfect cantilever. It is easy to perceive that in this case a complication occurs in the estimation of the strains. The bridge must be designed with respect to the load it has to carry, on the principle of a girder supported at both ends, and with respect to its own weight, as a girder fixed at one extremity and free at the other, that is, on the principle of the cantilever. The importance of this complication is only fully perceived when we come to consider the difference both in the nature and amount that prevails in the strains upon cantilevers and upon girders. In an ordinary girder the strains upon the upper flange are compressive, and tensile upon the lower; but when we convert this girder into a cantilever, these

strains are reversed, becoming tensile in the upper and compressive in the lower flange. It is scarcely necessary to point out that this fact would alone suffice to forbid the employment of cast iron in girders of this kind, which act alternately on one principle and then on another. But it is not in the flanges alone that the variation in the strains occurs. They also take place in the bars composing the web, which is perhaps of more importance still, as a bar that is designed and proportioned to bear safely a given tensile strain, will not carry the same amount when it is one of compression. The practical point to be looked at in these instances is the ratio between the weight of the bridge and that of the load it has to carry. This proportion will determine upon which principle the bridge must be designed, and what concession must be made to both of them. It has been hitherto assumed that the movable bridges slue or swivel round upon one or other of their supports, but there is another method of opening and closing the opening which is sometimes to be preferred. Instead of causing the bridge or half bridge to revolve upon its pivot like a door upon its hinges, it can be drawn backwards and forwards in a perfectly straight line. We might term these telescopic bridges. In a crowded waterway, where space was valuable, this plan would be found very advantageous, as no room would be required on one or both sides for the structure to swing back to the recess provided for it in the masonry. But this advantage is counterbalanced by the circumstance that a space must be kept clear on land in the rear of the bridge for it to be drawn back into. The question is reduced, therefore, to one of land *versus* water room, and the especial features of each example must decide it. There is no doubt that the plan of constructing the bridge all in one makes it steadier under traffic; but this defect in the semi-arch system proceeds solely from employing a faulty principle of securing the two projecting halves when they are in contact. When closed, the two semi-arches do partake more or less of the stability of the entire arch; but reliance must not be placed upon this, as any imperfection in the method of junction would at once destroy the value of the contact and place the two halves of the bridge in the position they should always be theoretically supposed to occupy.

DETERMINATION OF PURITY OF METALS BY THE FORM OF THEIR DROPS.

Translated from "Polytechnissche Journal."

At the May Meeting (1870) of the Prussian Society for the Advancement of Industrial Trades, Dr. Quincke, of Berlin, described a new method of determining the purity of melted metals, and of various chemical combinations by the height of the drops which are formed by them upon a horizontal surface. By the height of a drop, such as is formed by dew upon a leaf or by quicksilver upon glass, is meant the vertical distance of the horizontal plane from the vertex of the drop surface. This altitude is nearly constant, and is independent of the diameter of the drop if it is not greater than 20 millim.

If large flattened drops of the melted substances are formed at the lowest temperature possible, their altitude is the same as that of mercury, or it is obtained by multiplying the altitude of a large mercury drop by the square root of some integral number—2, 3, 4, etc.

The following substances give the same altitude of a melted drop as mercury: lead, bismuth, antimony, the chlorides, fats, sugar, etc.

An altitude about $\sqrt{2}$ times as great is obtained from melted ice (water), platinum, gold, silver, copper, phosphoric, carbonic and sulphuric salts, and glass; about $\sqrt{3}$ times as great from melted zinc and palladium (iron). Drops of melted sulphur, phosphorus, selenium, and bromine, are the lowest; their altitude being about $\frac{1}{\sqrt{2}}$ times that of mercury drops. The height and form of melted drops are the same as those of bubbles in the same substances under pressure of a horizontal plate.

The altitude of large flat drops or bubbles is less if their surface is covered with a thin coat of some fluid. A fluid coat less than the millionth of a millimetre in thickness is sufficient to reduce the altitude of melted drops in a sensible degree. A maximum of depression ($\frac{1}{4}$) occurs when the coat is $\frac{50}{1,000,000}$ of a millimetre in thickness, which is about $\frac{1}{10}$ of the length of a light wave. The presence of very small quantities of substances may be proved in this way to a degree of delicacy unequalled by any other method of observation except that of the spectroscope.

A trace of oil on a drop of dew or a bubble of air in water, and a trace of lead applied to a drop of melted silver, reduced the height from 4 to 2.8 millimetres, so that unpractised eyes could easily discern the difference. Substances which oxidize easily in the air should be melted and tried in some indifferent gas, like carbonic acid gas.

Large flat drops of iron from several mills, with surfaces coated with oxide, all had the same altitude of 5.2 millimetres. Workmen in foundries are in the habit of judging the quality of cast-iron by the form and condition of the drops. The speaker thought the careful investigation of the forms and altitudes of melted drops might prove an important aid in determining the properties of metals.

PROOF STRENGTH OF CHAINS.

From "The Building News."

Unless we regard the word chain to signify merely an assemblage of similar parts in which the total length bears a very large ratio to the lateral dimensions, the term suspension chain as applied to a bridge appears to be a misnomer. In all modern examples of suspension bridges the supporting chains consist either of numerous strands of wire twisted together so as to form a large wire rope, or of long bars united at their extremities by pins passing through eyes. The heads of the bar in which the eye-holes are made may be welded on the bar, or, by a new process, rolled at the same time with it. The latter is a very great improvement upon the former operation and should always be resorted to, notwithstanding the additional expense. It will be admitted that neither of these instances answers exactly to the popular idea of a chain, nor the signification which, constructively speaking, is generally attached to it. In a wide sense, anything that could assume the contour of the catenary curve would be a "catena" or chain, but as we are not at present inquiring into the derivation of the word, but into the practical value of the constructive agent it represents, we shall pass on to the more immediate subject of our article. Probably one of the most extensive and important uses to which chains are applied is in connection with shipping. Indeed, so well-known is the employment of iron in this capacity, that it is a very common occurrence to witness in the specification of a bridge, roof, or other engineering and architectural work, in which a large quantity of iron is wanted, the quality named as the "best cable iron." This naturally implies that the iron employed in the manufacture of cables is of a superior description, and when it is considered how many human lives, as well as much valuable property, is constantly depending upon the soundness and strength of chain cables, it is evident that they should be of the best material. Independently of these reasons, which are more than sufficient to render the above requirements indispensable, the nature of the strain to which chain cables are subjected is of a very trying description. It is far more severe than that which would result from the application of a weight merely requiring to be sustained at the end of the chain. The terrible and sudden jerks that cables are continually undergoing tax their strength and tenacity to the utmost. Engineers are well acquainted with the fact that a chain, or indeed any section of iron, will break with a much smaller weight when suddenly and violently applied, than it would when the same weight is "laid on" gently.

Most of our readers are probably familiar with the appearance of a chain cable. The links are oval in shape, and a small cross piece, technically termed a

stud, is inserted across them, in the direction of the minor axis or smaller diameter. This stud is of cast iron and its use is obvious. When the links are subjected to sever strain, they have manifestly a tendency to "draw," that is, to lengthen in the direction of the longer diameter, and to shorten in that of the shorter. The stud prevents this result and keeps the sides at their proper distance apart. The strain upon the link itself is tensile in character, but compressive upon the stud, which is thus made of cast iron, as the resistance of cast iron to compression, compared with that of wrought, is nearly double. On the other hand, the tensile strength of wrought iron is more than three times that of cast, so that each material is selected for the duty it can best fulfil. In previous articles relating to the strength of girders and various sections of iron, the influence of form or shape has been more than once conclusively shown to very considerably modify the actual resisting powers of the material. A very pertinent question in connection with the present instance arises. Does the conversion of the bar iron into the link of a chain increase or diminish the original strength of the metal? As a rule, iron is not improved, so far as either its tensile or compressive resistance is concerned, by any process of forging or welding. The science as well as the manipulative skill of the time have brought the two last mentioned operations to a degree of perfection that had not been attained to previously, but in spite of all the care and skill at our command, the "weld" can never be made so strong as the solid bar, or whatever other section of iron may be submitted to the process. At the same time, while it may be freely admitted that the "weld" is not equal in strength to the rest of the bar, it is a mistake to suppose that a "good weld" cannot be made. Some engineers and architects go so far as to set their face altogether against welds, but this is mere prejudice, and may very possibly arise from not possessing a thorough acquaintance with practical work and with the resources of a large and extensive "smithy." We have known instances in which a welded bar has been tested *á l'outrance*, and the solid bar has given way before the weld. This must be received as an exceptional case, but it nevertheless proves it is possible to effect this operation without deteriorating the resisting powers of the metal. To return to the question respecting the manner in which a bar of wrought iron is affected by its conversion into an oval-shaped link. Experience has shown, taking the average of superior and inferior qualities of iron, that a bar loses about a third of its ultimate strength by being converted into the link of a chain.

From what has been stated regarding the nature of the strains that chain cables have to undergo, and the serious liabilities contingent upon their parting, it will only be expected that the authorities should have taken some measures to insure their being of sound and durable manufacture. Without for a moment underrating the claims of the mercantile department, the Royal Navy has to be first considered. The weight and size of the vessels, the complement they carry, and the large outlay incurred in their building and armament, demand that due care should be taken that they are not lost for the want of good cables. With the view of providing this requisite, the Government has adopted a test or proof-strain for all chain cables intended for vessels belonging to the Royal Navy. If we suppose a bar of a given sectional area bent into the form of a link, the proof-strain demanded by Government is equal to $11\frac{1}{2}$ tons per sq. in. of the link. This test is calculated for one side of the link, so that the proof-strength of the whole link must be equal to the ultimate or tearing strain of the bar from which it is manufactured, supposing always the iron to be of superior quality. If it is not so, the link will not stand the test. This is a very severe test, but not more so than the nature of the case demands. In addition to the proof-strength of the chain being tested so far as regards the resistance to a tearing or tensile strain, it is also submitted to ordeals of a more trying character, and which are more in consonance with the actual description of strain it will have to withstand when undergoing real work. Heavy and sudden blows are inflicted upon some of the links while they are under strain, in order to test the value of their resisting powers to shocks and violent vibrations. As in the course of their duty they will have to undergo repeated strains of this description, the

precaution is not only justifiable but commendable. It may be urged that whatever may be the actual proof-strength of the iron it does not necessarily indicate the quality. A bar of iron may be sufficiently strong to withstand the proof-strain successfully, but its ultimate strength may be scarcely anything in excess. There would in such a case be nothing to spare, no margin of safety to rely upon, supposing that on some occasion or other the strain in practice should exceed the proof-strength of the material. Some test therefore is evidently required respecting the quality of the iron. In fact, if the quality of the iron could be ascertained, à priori there would be no necessity for any tests whatever, as iron of such a quality will always bear a strain of a commensurate intensity. The Government authorities test the quality of the metal in the chain cables submitted to them for ascertaining the proof-strength, by cutting out a link here and there from any part of the cable and breaking it. The character of the fracture, combined with the results of the other experiments, are sufficient and accurate indications of the quality of the iron, and the skill and care displayed in its manufacture and conversion into links. It cannot be too carefully borne in mind that the strength of a piece of iron is not an unequivocal test of its quality. A bar of iron that is not by any means homogeneous throughout its whole length, may yet be able to resist the testing strain put upon it, simply because the strain may not affect its weakest part. It is uniformity of strength and of resistance that is wanted in all iron-work, more especially in such an example as a chain, in which the slightest weakness in one of the component parts will cause the failure of the whole. A single faulty link will cause the cable to part, the ship to be wrecked and the crew and passengers to be lost. It is scarcely possible that the proof-strength of a chain cable could be tested link by link, except so far as that the transmission of strain throughout the whole may be regarded as a valid criterion; but by cutting a few links indiscriminately a fair estimate may be unquestionably made of the soundness of the entire length. Should a single link prove defective while undergoing the ordeal, the whole chain is not condemned on that account, but a new link is substituted, and the cable submitted to a further test. Manufacturers rarely send chain cables for testing that are below the standard, for the best of reasons: in the first place, it would be to no purpose, and in the second they would damage their own reputation for good work.

ON THE GIBRALTAR CURRENT, THE GULF STREAM, AND THE GENERAL OCEANIC CIRCULATION.

By DR. W. B. CARPENTER, F.R.S.

From "The Artizan."

The author commenced by an allusion to the investigations carried out for 3 years past, with the aid of the Hydrographic Department of the Admiralty, into the nature of the deep sea, and detailed the observations conducted by himself and Commander Calver of H.M.S. Porcupine, on the outflowing undercurrent at the Straits of Gibraltar. He showed on what insufficient observations the supposition of a current flowing outward from the Mediterranean had hitherto rested. An outflow of this nature was a necessary hypothesis; for the excess of saltness caused by the great surface-evaporation (naturally of pure water only) from the Mediterranean would otherwise be most sensibly felt in the waters of that sea; and this was not compensated by rainfall and rivers, or by the water flowing in to restore the level, which consisted of Atlantic salt water setting inwards, in a surface-stream, at the rate of 3 miles an hour. It was singular that the shallowest part of the Straits was not where they were narrowest, at Gibraltar, but much farther to the west, between Capes Trafalgar and Spartel; the sea-bottom slopes westward from Gibraltar, where it averages about 400 fathoms, to the western extremity, where the depth is scarcely 50 fathoms on the northern, and 200 fathoms on the southern half. After repeated observations, aided by the in-

genious mechanical contrivances of Commander Calver, the existence of a deep-water current setting outwards was finally established. It was true the stream must thus be supposed to flow up-hill along the sea-bottom from Gibraltar to the shallow ridge westward (the true limit of the Mediterranean basin); but this was shown to be the natural action of flowing water under such circumstances. Dr. Carpenter then explained that this interchange of water between the Mediterranean and the Atlantic was in accordance with a simple physical law, and that the same law, in its wider application, threw a new light on oceanic circulation and marine currents throughout the globe. As the surface water of the superheated Mediterranean ascended by evaporation, leaving its saline constituents behind, the remaining water, becoming denser and heavier by its increased saltness, sinks beneath the less salt Atlantic water flowing inward by the Straits, and is eventually forced outward as an under-current, as proved by the recent observations. If the accession of fresh water by rain and rivers in the Mediterranean had equalled the amount evaporated from the surface, instead of being much the reverse, there would have been no current and counter-current at the Straits of Gibraltar; and if the fresh-water supplies had been greater than the evaporation, there would have been a surface-current outwards of the lighter water. This last hypothetical condition is precisely that of the Baltic in regard to the North Sea, in which case there is a surface-flow of fresh water outwards and an under-current of heavier sea-water inwards. It was obvious that a like circulation of waters, the lighter above and the heavier below, in opposite streams, must take place in any case in which a want of equilibrium between two columns of water is constantly maintained, whatever might be the agency producing it. A great difference of temperature at two extremities of a great ocean must cause two such currents to be set going on a vast scale; for, as in the cold area, water contracts and becomes heavier by the cold, its level must sink, and the general oceanic level be continually maintained by a flow of warmer and lighter water from the warmer areas of the same or adjoining ocean. The recent investigations had supplied results in accordance with this hypothesis. Such circulation of oceanic water being universal, Dr. Carpenter had found reason to doubt the received opinion of the Gulf Stream being the direct cause of the set of warmer water towards North-Western Europe and into the Arctic circle; the Gulf Stream was rather a local accident of the oceanic circulation, resulting from the configuration of the land past which it flowed, and its existence as a stream much beyond the banks of Newfoundland was not proved. A beautiful experimental illustration of opposite currents was exhibited by the author. At the extremities of a long glass trough, filled with water, upright tubes were fixed; one of which was filled with ice, and the tube at the opposite end heated by a gas jet. On blue coloring matter being inserted at the cold, and red at the warm end, the two separate streams became visible, the red near the surface and the blue below.

AUSTRALIAN TELEGRAPHY.—The advices received with respect to the progress of the great overland Australian telegraph are considered satisfactory upon the whole. Nothing very definite appears, however, to have been yet attained. When the last mail left Adelaide, Mr. Todd, superintendent of telegraphs in Australia, had not yet returned from the neighborhood of Mount Margaret, the furthermost outpost of settlement on the southern side of that portion of the Australian continent under the jurisdiction of the South Australian Government. Mr. Todd's desire was to see the great work undertaken fairly put in hand before he left Mount Margaret.

NEW ZEALAND MAILS.—On dit that the New Zealand Government proposes to enter into an arrangement with an American Steam Shipping Company for the conveyance of mails from Great Britain *via* New York, the Central Pacific Railroad and San Francisco. The subsidy is to be £75,000 per annum.

THE English papers speak doubtfully of the entire success of the Sherman Steel Process.

PROPORTION BETWEEN STRENGTH AND SIZE OF IRON.

From "The Mechanics' Magazine."

It has been established by experiment that small sizes of iron are proportionately stronger than larger ones. In other words, two bars of iron, containing each one square inch of sectional area, will be stronger than one bar containing two square inches. This discrepancy is not confined to bars and rods, but extends to iron of various forms. Thus, small forgings are generally tensilely stronger proportionately than large ones, although it must be admitted that the difference in strength which may be manifested depends very much upon the skill and care bestowed upon the workmanship. Uniformity of strength in any single piece or compound structure of iron must be synonymous with a homogeneous consistency of all the parts. Thus, if a bar or plate of iron be not homogeneous throughout, its strength will be only equal to that of its weakest part. As it is always more difficult to manufacture large sections of iron than small ones, so that the element of homogeneity be maintained, it is evident that the latter have the best chance of being endowed with uniformity of strength. Arguing solely upon these grounds, it would seem that only very small sections and sizes of iron should be used in order to obtain the maximum value out of the material. The minimum sectional area that can be given to iron intended for constructive purposes, is that of wire, and consequently by analogy iron wire should be used instead of bars, rods, and other forms. However correct this purely theoretical argument may seem, there are many practical reasons which render the carrying of it into execution impracticable. In the first place, the theoretical assertion will only hold for those cases in which the strain to which the material is to be subjected is of a tensile character. Obviously iron wire by itself or in a multiplicity of strands so as to constitute a wire rope, is altogether unsuitable to withstand strains of compression. It is utterly deficient in lateral rigidity or stiffness. Viewed in the most favorable light, namely, that in which it is acted upon by strains only of a tensile nature, there are many objections against its employment, notwithstanding its proportional greater strength than bars of the same sectional area. It will be shown presently what these objections are, and how they tend in practice to counterbalance the advantages which theory confers upon the use of wire ropes. But, in the first place, it will be interesting to notice what is the difference in the actual tensile strength of iron wire and that material in the shape of bars and plates. The unit of comparison will in all cases be that of one square inch of sectional area.

The strength of iron wire, similarly to that of other forms and sections of the metal, will vary with the quality, and can be procured good, bad, or indifferent, but in making an estimate of it, the correct method is to take such a limit only as has been attained in actual practice. It is frequently the custom with engineers to specify that the iron to be supplied for bridges and other works of construction shall be of a superlatively good quality and able to stand a test of the severest character. This we believe to be a mistake. Any very extraordinary excellence in one particular is sure to be more than equalized by a deficiency in another. Some of the tests insisted upon by engineers are simply ridiculous, and merely serve as a premium for ingenuity in evading them. The tensile strength of iron may be regarded in two different lights—one in which the strength of a single wire is taken into consideration, and the other in which that of a number of them combined in the form of wire rope is the object sought. It has been proved that an iron wire having a sectional area of 0.0078 square inches, bore a breaking tensile strain of 0.28 tons, which would be equal to 36 tons per one square inch of area. The tensile strain of the best iron bar cannot be taken at more than 26 tons, so that there is a large preponderance in favor of the wire. But a still greater difference is manifest in the case of a rope or number of strands, and a well known instance is that of the iron cable supporting the Niagara Bridge. The tensile strength of the cable per square inch is equal to 44.5 tons, and there are 60 wires to one square inch of section. Consequently the sectional area of each wire is 0.0166 square

inches, and its ultimate tensile strain, supposing all the wires to be of uniform strength, would be equal to 0.738 tons. We may now compare these two cases. Without taking into consideration the question of relative sizes, the ratio between the wire having a sectional area of 0.0078 square inches, and that of 0.0166, would give the ultimate strength of the latter equal to 0.60 tons instead of 0.738 tons. This slight excess must be attributed to the circumstance of a number of wires being bound together, thus constituting a practical corroboration of the motto, "in union there is strength." In estimating the strength of iron wire, care must always be taken to ascertain whether it has been annealed or not, as the process seriously diminishes the resistance of the metal to a tensile strain. Moreover, the average tensile strength of ordinary iron wire will not equal that which has been given here, but when it is required for important engineering works there is special care bestowed upon its manufacture. Like every other form of iron, wire and wire rope can be had of bad quality, unless it be specified to the contrary, and precautions taken to be certain that the specification is complied with.

We have now to consider the practical part of the question, and inquire into the reason why it is that, with so high a power of resistance, iron wire and wire rope is not employed more frequently in construction. It has been already mentioned that it is useless as a material for resisting strains of compression. Whether in single or manifold strands, it is alike unsuited to strains of that description. But bearing in mind the high tensile strain which it will withstand when properly manufactured for the purpose, one would expect, at least, that advantage would be taken of this property it possesses, whenever the opportunity occurred. But experience and the practice of engineers demonstrate that the contrary is the fact. There may be some excuse for not employing iron wire as tension bars or ties in many engineering structures, because under certain conditions attending the passage of a heavy rolling load, the tension bars may be subjected to strains of compression, which, although slight in amount, would be fatal to the adoption of wire as the form of material for them. Again, it is not merely this want of resistance to strains of compression that unfits it for many positions in which it might be safely and economically employed, but also the very small power it possesses of resisting a tendency to sag. So long as a straight bar, rod, or wire is of reasonable length and strained tightly, it will be practically free from sagging or deflection. But when it becomes very long and the strain upon it slackens, it will be certain to sag. It is manifestly for this reason that king rods are employed in iron roofs when the ties are horizontally extended from the end of one rafter to that of the other. So long as the tie rod of a roof is horizontal and supports no flooring or ceiling of any kind, the strain upon it is a direct pull, and it is supposed to undergo no transverse strain except that resulting from the action of its own weight. That there is a tendency in all ties to drop or sag, is shown by the fact that in iron roofs where flat bars are used for the ties, they are invariably placed on edge so as to give the bar the advantage of the depth in resisting the tendency to deflect in the centre. In most bridges and other structures the various parts are rarely subjected to only one description of strain. If the load were always stationary and uniform, then the strains upon the different members would always be of the same character; but loads varying in amount and position completely destroy this simplicity of action, and, moreover, sometimes very much complicate the design. There are only two descriptions of structure in which the nature, although not the amount, of the strains is independent of the amount and position of the load. They are the arch and the suspension principles. In the former the whole undergoes strains of compression, and in the latter, of tension. In suspension bridges, therefore, we appear at last to have arrived at the proper sphere for the application of iron wire. Yet iron wire is not by any means exclusively used in suspension bridges. Many engineers object to its use altogether, notwithstanding the undoubted fact that the cables of the Niagara Bridge stood a breaking weight of 44½ tons per square inch of sectional area. It might be inquired, why is this? Surely a section of iron that can stand a tensile strain of nearly double that which the same material in another form can, is the proper section to employ in situations

where its distinguishing characteristic is brought into play. It is just here that one of those instances occurs where the theoretical man is at fault, and unless he combines practical knowledge with an acquaintance with science, he inevitably comes to grief. Omitting all consideration of single wires, the question is reduced to that of ropes or cables in which a number of strands are wound or twisted together, and in which the strength of the whole is dependent upon that of its individual components.

There are two grave objections to the employment of iron cables. One is that as the strength of the entire rope is made up of the strength of all the wires together, it is quite possible that some of these may be stronger than others, and some weaker. The testing of the cable is not a criterion of the separate value of its components, and consequently some strands may be more severely strained than others. Again, by the nature of the manufacture, it is not an easy matter to insure that a uniformity of strain shall be imparted to every wire in the cable, supposing that they are all equal in tensile resistance. There is a great difference in the fracture of a cable and a bar or rod of iron. The latter will break right in two, so to speak; but in the former, failure ensues by the parting of the strands, clearly intimating that one of two circumstances takes place. Either the strain is unequally distributed, or, what is probably the case, the resistance of the wires is not uniform, and consequently the weaker ones yield and the cable parts before its ultimate resisting powers are called into play. In all combinations of parts which tend to constitute a certain total sectional area of metal, the strength of the whole is estimated at so many tons per square inch of that area, and the only difficulty to be overcome is, to insure that each part shall be able to bear its proper share of the load. Otherwise, upon the well known engineering principle that no constructive design is stronger than its weakest part, if one part or member be weaker than another, the whole structure suffers in consequence, and will yield to a less severe strain than it ought to do. It may be mentioned that tests *a l'outrance* are not necessarily an accurate indication of the strength of a cable, beam, or girder. Examples of construction, after being tested very severely, have subsequently yielded to a strain of considerably less severity. The second objection urged against the use of iron wire cables is that it is impossible to obtain any idea of the amount of corrosion that may be in progress in the interior of it. Some of the wires might be eaten away to almost nothing without the least symptom of the evil being apparent superficially, and, what is worse, it could not be detected without practically destroying the cable. Undoubtedly the use of iron rope is attended, omitting the objections alluded to, with economy in suspension bridges, but it is nevertheless not universally employed in them. It is used in the instance of Lambeth Bridge, which was designed with especial regard to cheapness and ugliness, but in the handsome structure at Chelsea, suspension bar links are substituted with great advantage to the architectural merits of the bridge. Summing up the whole subject, it must be admitted that while the smaller sections of iron are unquestionably proportionally stronger than larger ones, yet in practice this theoretical superiority is counterbalanced by other disadvantages which preclude that extended application of the principle which, under other circumstances, might be considered advisable. Obviously the carrying out of this diminution of section to an extreme point would terminate in a *reductio ad absurdum*, for it would indicate that the maximum economical results would be obtained by using iron in the form of mere threads or filaments. But strength to resist any particular description of strain is not the only property demanded of a constructive material. A certain degree of stiffness and inherent solidity is also required. Moreover, the smaller the section of iron the greater the effect of corrosion and other extraneous causes of deterioration. We know an instance in which an iron bridge was erected over an arm of the sea, and in which the bars were increased from $\frac{1}{8}$ in. to $\frac{1}{4}$ in. in thickness beyond that which the strain rendered necessary, on purpose to allow for the action of corrosion by the sea air.

THE deepest excavation in the United States is a copper mine near Lake Superior. It is 1,300 ft. deep.

THE SHERMAN PROCESS.

From "The Engineer."

About twelve months since, Mr. J. E. Sherman, an American steel-maker, came over to this country to introduce a new process of manufacture intended to improve inferior qualities of iron. Mr. Sherman commenced his operations at Chatham, where he worked for our Government, it is said with success. Subsequently he visited various establishments in this country, and tried his process on a very considerable scale. Reports of his progress have found their way into many local papers. Some of these condemned, others praised the process; but it does not appear that any articles have been written on the subject as yet by men who, possessing a competent knowledge of the manufacture of iron, also saw the process carried out, and the resulting iron tested properly. A few months ago Mr. Sherman's agent called at our office and showed us samples of wrought-iron and steel, apparently of excellent quality, produced by the Sherman process; but as we did not see these made, we declined to take any notice whatever of the matter until such time as the inventor might be in a position to supply us with the fullest information. We confess that we regard with the utmost doubt all processes—and they can be counted by the hundred—which are intended to make naturally bad iron good by the aid of chemicals, or, to use an ironmaster's phrase, by "physicking." On the other hand, it would be obviously improper to draw a fixed line and assert that any method of manipulating iron beyond that line must be a failure. We, therefore, reluctant to condemn the Sherman process as we were to praise it, suspended our judgment until we knew more about it. During the last few months Mr. Sherman has been at work for Sir John Brown & Co., Sheffield, the firm placing every possible facility in his way for experimenting, and on Friday and Saturday last we visited the works by Mr. Sherman's invitation, and made ourselves acquainted with the details of the entire process as applied to the manufacture of Bessemer steel, crucible steel, and puddled iron. Mr. Sherman placed every possible opportunity of obtaining information at our disposal. He made no secret of anything. He left the conduct of the experiments in our hands; in a word, we cannot speak too highly of his straightforward dealing from first to last. The experience of two days with a new process like this is, however, not sufficient to enable us to pronounce any decided opinions of value as to its merits. We shall therefore confine ourselves strictly to a statement of what we saw done, begging our readers to bear in mind that it was absolutely impossible that the results of the experiments could be vitiated by unfair dealing, or even by the bias of an inventor's opinion. Those who peruse this article will therefore be able to form an opinion for themselves as to the merits of the process, which we for the moment decline to give. What a private individual thinks can affect only himself; an expression of our sentiments under the circumstances might be unfair to Mr. Sherman or to the great body of iron manufacturers in this kingdom.

Before going further it will be well to explain precisely what the Sherman process is. Mr. Sherman takes for a basis the argument that the practical difference between what is known as good iron and bad iron is, other things being equal, that good iron is nearly free from sulphur and phosphorus, while bad iron contains either or both, the first making it red short, the latter cold short, while very bad iron, containing both sulphur and phosphorus, is both red short and cold short. Reasoning from these premises, he assumes that if the sulphur and phosphorus can be eliminated, bad iron may become very good. But the affinity for iron of the two elements we have named is known to be excessively strong. In order to get rid of them something must be introduced into the puddling furnace, the crucible or the converter, which will not only have a greater affinity for sulphur and phosphorus than iron has, but which also admits of being driven off at a high temperature. Mr. Sherman has sought this something for eleven years, and he claims to have found it in iodine, almost any compound of which answers his purpose, but he prefers to use it in the form of iodide of potassium, to use the old, and among

ironmasters as yet best known, chemical terminology. He asserts that the iodine combines with the sulphur and phosphorus, hunts them up throughout the mass of melted metal, combines with them, and carries them away partly in the cinder, partly in the gaseous state due to a high temperature. Mr. Sherman has told us the precise proportion of iodine which it is necessary to use, which is very small, but as it would not be difficult to practise his invention without his knowledge, and so defraud him of his royalties, we do not consider ourselves at liberty to publish the minute details of the process on which it is claimed its success in great measure depends. We write this article, however, in such full possession of them as could be acquired by Mr. Sherman's instructions, and the fact that we actually applied the process ourselves at Sir John Brown's works.

On Friday morning we commenced operations by witnessing the application of the process to the manufacture of Bessemer steel, two charges being blown in our presence. The method of introducing the "physic" into the converter is extremely simple. A short length of pipe is screwed vertically into the elbow where the trunnion of the converter joins the blast main; this pipe is fitted with two stopcocks, placed a few inches asunder. The lower one is closed just before blowing begins, and the upper one opened; the iodide of potassium in coarse powder, is then poured through the opening in the first cock, into the space between it and the second cock. The upper cock is then shut, and blowing begins; after the process has reached a certain point, determined by spectroscopic examination of the flame from the converter, the lower cock is opened, the iodide of potassium at once falls into the trunnion and is blown right through the molten metal by the blast. The following particulars of the second charge we saw blown will give an idea of the nature of Mr. Sherman's operations:

The charge consisted of nearly 7 tons, thus made up: Millom hematite, 25 cwt.; West Cumberland hematite, 25 cwt.; Askam hematite, 20 cwt.; Harrington hematite, 40 cwt.; Glengarnock common Scotch, 20 cwt.; Spiegeleisen, 9 cwt.; the ordinary mixture used being the same, with the exception that 20 cwt. of Cleator hematite takes the place of the Glengarnock pig, which is rendered available by the aid of the Sherman process. It was, in short, introduced experimentally. The charges for both the blowings we saw were the same. We did not take the time spent in blowing the first charge. Blowing began with the second charge at 11.4 A. M.; at 11.15 the cock was turned and the iodide of potassium introduced. Blowing ceased at 11.21, and the spiegeleisen was introduced at 11.22. The charge was immediately tapped into the ingot moulds without further blowing. Throughout, the pressure of blast was a little over 13 lbs. on the sq. in., and the iron, no doubt, from the presence of the Scotch pig, worked exceedingly hot. At the moment the iodine was introduced, the flame escaping from the mouth of the converter became augmented in volume and intensity. We cannot better describe the change than by stating that the flame became more solid. The proper time for introducing the iodine is just about the moment when the carbon lines first appear in the spectrum. At the instant the iodine is introduced, all the lines become strengthened; but the effect produced is so transient, that it would require an extended series of examinations to determine exactly what is the nature of the change effected in the spectrum of the flame. This, we may add, is a point of much importance, to which spectroscopists would do well to direct their attention. We believe we are correct in stating that Mr. Browning is now engaged in the construction of an apparatus by which the spectrum can be thrown on a small screen to be examined by direct vision. Such an apparatus, if portable and handy, cannot fail to prove valuable to steel makers.

As soon as this charge was blown, we proceeded to test the process in the puddling furnace; but inasmuch as we resumed operations with the converter, on Saturday, it will be more convenient to say here all that we have to say about the Sherman process as applied to the Bessemer process, and then turn to the puddling furnace and the crucible. It will be understood that Mr. Sherman is working in the converter tentatively. The 1 ton of Scotch pig was introduced experimentally, but before that several ordinary charges were blown with iodide of potassium added. These were rolled

into rails. The opinions we heard expressed in the rail mill were to the effect that the percentage of waste was reduced by about one-half; that the metal worked kindly, and finished well. The statistics of four 7 ton charges ran thus: The charges produced 83 rail blooms weighing 640 lbs., or 23 ton 1 cwt. 1 qr. 20 lbs. These blooms were rolled into 83 rails 30 ft. long, and weighing 57.5 lbs. to the yard. Eighty of the rails were good, three were defective. About 20 cwt. of scrap was produced in cutting the blooms to the proper length for the rails, and about 4 tons of iron were lost in blowing the four charges, heating the blooms, etc. On Saturday we saw a portion of the charges containing Glengarnock pig worked under the hammer. During Friday night four rails had been rolled from the only ingots ready at the time, with perfect success. The ingots worked under the hammer as perfectly as any Bessemer ingot could work. We had some of the crop ends forged into bars about 3 in. sq., under a 10 ton hammer, without the slightest symptom of splitting or cracking.

On Saturday morning Mr. Sherman advanced a step further, and blew some charges with an increased proportion of inferior iron. Each charge consisted of Glengarnock Scotch pig, 40 cwt.; Harrington hematite, 40 cwt.; West Cumberland hematite, 30 cwt.; Askam hematite, 20 cwt.; Spiegeleisen, 9 cwt. We witnessed the blowing of one charge only. The blast was turned on at 10.14. The iodide of potassium was introduced at 10.25, with, as before, an immediate augmentation in the volume of flame, and the operation was completed at 11.30. We did not see any of the ingots made on Saturday worked up, but we have since been informed that they were quite satisfactory.

We shall now recount our experience of the use of iodine in the puddling furnace. The iron was made on Friday, and on Saturday the tests of the bars were carried out by Mr. Hunt, who conducts all the tests made at Sir John Brown and Co.'s works.

Two puddling furnaces in what is known as the "south forge" were placed at our disposal. These furnaces are numbered respectively 10 and 11, and we decided that a charge should be worked into wrought iron in No. 10, and another charge worked into what is called at Sir John Brown's "steel iron"—in other words, puddled steel—in No. 11. The whole difference in quality was due to the fact that the metal was drawn rather green to make puddled steel. In every other respect as regards fettling, etc., the process of manufacture was identical. As so much depends on the method of fettling practised, we took special care to ascertain the nature of the system adopted, which was, as far as we could see, precisely the same as that used in working the other furnaces. The puddlers were left strictly to their own devices, receiving no instructions either from us or from Mr. Sherman. The furnaces are of the ordinary water bosh type, each delivering the products of combustion into the vertical flue of a stack boiler. The method of proceeding was as follows:—The bottom of the hearth was cooled down with a few shovelfuls of cold water. When this had dried off, about 30 lbs. of ball furnace cinder were put into the furnace close to the throat; the rest of the hearth was then fettled in the ordinary way with hematite ore in paste. Just before charging, two small shovelfuls of mill scale were spread evenly over the hearth bottom, and the pig was then introduced. The iron used was Linthorpe No. 4, a metal made almost in the centre of the town of Middlesbrough, costing 40s. to 45s. per ton, and never used by itself in ordinary practice at Sir John Brown's, as it is found to be both red and cold short. The charge weighed as nearly as might be 4¼ cwt. No. 11 furnace was charged at 11.52. The iron was all melted about 12.24; at 12.37 it began to rise, but was not quite boiling. At this point we ourselves, at Mr. Sherman's request, introduced the dose of iodide of potassium, which was wrapped up in paper, put into a ladle, and covered with a few handfuls of common salt, which is used to confine the iodine and prevent its rapid volatilization. The damper was dropped for a few minutes. The immediate result of the introduction of the iodide, which was thrown in through the rabble-hole, and rapidly stirred into the metal, was the production of a multitude of tiny jets of white flame from the surface, which quickly disappeared. The metal worked hot and boiled well. It was puddled carefully, but not with more care

than should always be bestowed on the operation. At 1.22 the first ball was drawn. The charge was worked into four balls, which were taken at once to the steam shingling hammer. They shingled kindly and well, with the discharge of much fluid cinder. Still hot, the blooms were put into a ball furnace with a cinder bottom, brought to a good wash heat, and then taken to a second hammer, where they were reduced to billets about 4 in. square. No. 1 ball split under the hammer. Being the first ball drawn it was probably a little too green. It was returned to the ball furnace, re-heated, and hammered again. The second hammering it bore quite well. Balls Nos. 2, 3, and 4 worked as well as possible. They were then, while still hot, charged into a second furnace, re-heated, and rolled into bars $3\frac{1}{4}$ in. $\times \frac{5}{8}$ in. One of these bars was cut up, piled four high, and rolled into a billet $1\frac{1}{4}$ in. square.

Furnace No. 10 was fettled and charged as No. 11 in all respects. The iron was put in at 12.4. It was all melted about 12.27. The iodide was put in at 12.55, and the first ball drawn at 1.45. The subsequent processes were identical with those already described, with the exception that all the balls worked very well, both under the hammer and the rolls. It may be well to state here that the iron made in the south forge is used exclusively for conversion into steel for railway and other springs, of which the Company make enormous quantities. The Shermanized iron was treated in all respects—save the piling of one bar from the furnace—as though it had formed part of the regular production of the forge.

In order to test the quality of the iron produced we had all the bars marked. Those made in No. 10 furnace we called No. 2; but those made in No. 11 furnace No. 1, the latter being puddled steel, the former wrought iron. Bars of No. 2 and No. 1 were then cut into lengths of 22 in. and taken to the blacksmith's shop. No. 2 bore bending cold to an angle of about 120 deg., or nearly double, when a small crack appeared. The other end of the bar was then heated, split, and submitted to the well-known ram's horn test. A small crack appeared in one of the legs soon after bending commenced, but it did not extend. The other leg bent very kindly. The result of this test was pronounced quite satisfactory. The bar was then heated and punched, a succession of drifts being driven through the same hole —the bar being kept hot all the time— until it had reached a diameter of $4\frac{3}{4}$ in., or $1\frac{1}{2}$ in. greater than the width of the bar, the iron being reduced to a section of little more than $\frac{1}{8}$ to $\frac{1}{4}$ of an in. at each side, without a crack. This may be taken as conclusive evidence that the metal was not red short.

A similar test bar of No. 1 underwent the same process, which it stood as well. The ram's horn test, indeed, gave better results, as there was no crack.

One of the square billets from No. 2 bore bending double, cold, without crack or fracture of any kind save a small split in the side due to the imperfect welding of the pile in the rolls.

We then had a test bar of No. 1 planed on the edges, its dimensions being $2.01 \times .73$ in. This bar was then broken in the machine used by Mr. Hunt for carrying out all the tests made daily at Sir John Brown & Co.'s. The following are the results:

Test length	10 in.
Area of bar	1.4673 in.
Total strain	41.5 tons.
Strain per square inch	28.28 tons.
Elongation	20.2 per cent.
Length of longest inch	1.32
Reduction in area	25.17 per cent.

The fracture was partly crystalline, partly fibrous; the line of demarcation being well marked across the thickness of the bar. About $\frac{3}{4}$ths were crystalline, moderately fine; the fibres were rather coarse, but very clean.

A bar of No. 2, almost precisely similar, was then broken. It gave way at the first essay, with a very moderate strain, close to the gripping jaws. On examination a bit of fire-brick was found embedded in the iron at this point, which, of course, explained the breakage. As the bar was still long enough, a fresh hold was taken, and the test proceeded, with the following result:

Test length	10 in.
Area of cross section	1.3668 in.
Total strain	33.5 tons.
Strain per inch	24.6 tons.
Length of longest inch	1.18.
Elongation	11 per cent.
Reduction in area	15.2 per cent.

This bar was in every respect the worst of the whole lot, as was evident

from the character of the grain. It had probably taken up impurities from the falling of some small portion of the crown of the furnace during the operation of puddling. Although we do not regard it as a fair sample of the iron produced, we, in pursuance of our resolution to state exactly what results were obtained, think it right to place the particulars of the test before our readers :

From the billet made from the same charge we obtained the following results, which, it will be seen, go far to prove that test bar No. 2 was not a fair sample : A piece of billet iron No. 2, 22 in. long, was turned down for about 10 in. of its length to a diameter of 1 in. This was placed in the testing machine and broken. It gave way exactly in the centre of its length.

Test length	10 in.
Total strain	21 tons.
Strain per square inch	26.61 tons.
Length of longest inch	1.5.
Elongation	23.7 per cent.
Reduction in area	37.45 per cent.

The fracture was clean and good, partly fibrous, partly crystalline.

A test bar of No. 1, the same in all respects as the preceding, gave the following results :

Test length	10 in.
Total strain	21 tons 15 cwt.
Strain per square inch	27.18 tons.
Elongation	22.3 per cent.
Longest inch	1.57.
Reduction of area	43.2 per cent.

This bar stretched very equally, as shown by the numerous points of contraction found in the length of the piece. We refrain, at present, from pronouncing any opinion on the quality of iron manifesting the properties it was proved to possess by the foregoing tests.

We have now to consider the process as applied to the manufacture of crucible steel. We must premise that although we witnessed the production of crucible steel by the Sherman process, we did not see the steel so made tested. As, however, we are enabled to lay before our readers the results of the tests verified by Mr. Hunt, this is a matter of no consequence whatever. That the figures we give below are as truthful and accurate as possible is simply beyond question.

On the morning of Saturday, 2 crucibles were charged in the ordinary way with 50 lbs. each of iron cut off the bars described in our last impression. The iron was put into the white-hot crucibles with a charging funnel. The moment it was all in, a small quantity of iodide of potassium wrapped up in paper was thrown into each crucible on the cold iron. The lid was immediately placed on the pot and the furnace filled up with coke. The sole difference which we observed, or which existed, between the manufacture of the ordinary pot steel and Sherman pot steel was embodied in the facts, first, that the iron used was all made in the way already described from Linthorpe pig ; and, secondly, that a very small quantity of iodide of potassium was put into each crucible. That is all. The steel when properly melted was "teemed" into 2 ingot moulds. The resulting ingots were subsequently tilted into bars, specimens of which we have seen. It is indisputable that the quality is excellent, as shown both by the appearance of the bars and the following tabular statement of their qualities:

Tests of Steel Bars, Sherman Process. Crucible Steel—Linthorpe Pig.

No 1.

Test length	10 in.
Dimensions	0.49 in. × 0.49 in.
Breaking strain	11.25 tons
Per square inch	46.85 tons
Elongation	9 5 per cent.
Reduction in area	31.69 per cent.

No. 2.

Test length	10 in.
Dimensions	0.51 in. × 0.51 in.
Breaking strain	11.50 tons
Per square inch	45.09 tons
Elongation	12.3 per cent.
Reduction in area	41.89 per cent.

No. 3.

Test length	10 in.
Dimensions	0.55 in. × 0.55 in.
Breaking strain	16.50 tons
Per square inch	54.54 tons
Elongation	10 91 per cent.
Reduction in area	30.01 per cent.

Two bars an inch square were then turned down for a length of 22 in. in the middle, to a diameter of $\frac{1}{2}$ in. These were then twisted across cold by direct torsion. They both broke in the middle with $5\frac{1}{2}$ complete turns. A test bar $\frac{1}{2}$ in. sq. was then coiled cold into a helix of 7 coils, with an internal diameter of $5\frac{3}{8}$ in. The metal was pronounced by the men in the tilting-house to work as kindly and as well as any steel could work. A portion of this steel is now, we understand, being

used in the fitting shop in the shape of chisels and lathe tools, so far with excellent results.

We are enabled to supplement the information first published on this subject with the following particulars of tests of steel bars and rails made by the Sherman process in the converter. The bars were forged and tilted out of the croppings from rail billets before referred to. It will be as well to give the figures applying to the rails first :

Test of Steel Rails, Sherman Process—Bessemer.

No. 900 Blow.—Single-headed rails, 57 lbs. per yard. Weight of one ton falling 15 ft.; bearings 3 ft. apart.

1st test, one blow of monkey, deflection 5½ in.
2nd " " " " 5⅝ in.
3rd " " " " broke

No. 901.

1st test, one blow of monkey, deflection 5¾ in.
2nd " " " " 5¼ in.
3rd, 2 blows, 1st blow 5¾ in.; second blow 10½ in.

No. 5 test rail blow 901 already bent 10½ in., put upon end ; 2 blows of 1 ton each, 7 ft. fall ; rail broke. Total deflection, 13 in.

No. 921.—Test rail. First test broke.

The rail No. 921 was over-carbonized, possibly from the introduction of too much spiegeleisen, and was unfit for permanent way, being too hard and brittle. That it was, notwithstanding, admirably suited to other purposes, will be seen from the following figures :

No. 901 Bar.

Test lengths in all cases, 10 in.

Dimensions	0.58 in. × 0.575 in.
Breaking strain	14.50 tons.
Per square inch	43.48 tons.
Elongation	13.7 per cent.
Reduction in area	41.91 per cent.

No. 921 Bar.

Dimensions	0.56in. × 0.56 in.
Breaking strain	15.25 tons.
Per square inch	48.62 tons.
Elongation	11.5 per cent.
Reduction in area	32.52 per cent.

No. 945 Bar.

Dimensions	0.46 in. × 0.46 in.
Breaking strain	10 75 tons.
Per square inch	50.80 tons.
Elongation	6 per cent.
Reduction in area	22.88 per cent.

Cold Twists, Bessemer Bars.—No. 901 Bar.

Test bar, four turns. This test bar, plain all the length, ½in. square, broke in the die for holding.

Cold Twist.—No. 921 Bar.

Tests bars, inch square ends, turned down to ½in. diameter, for 22 in. in the middle, stood five turns each. Bars broke in the middle.

Cold Coiling Tests.—Bessemer Bars.

No. 901 test bar, ½ in. square, coiled into helical coil or spring). Four coils ; inside diameter, 3¾ in.

No. 921 test bar, ½ in. square. Five coils; inside diameter, 3⅜ in.

We have now placed our readers in possession of all the information we have been able to acquire so far concerning a process which it is thought by some people is only second to that of Bessemer in importance. If the theory of the action of iodine held by Mr. Sherman be correct, it is very possible that he will work a small revolution in the manufacture of wrought iron from inferior pig. We still reserve a decided expression of opinion as to the ultimate value of the process ; but it does not follow that we must, to carry out this intention, reserve our opinions as to the action of iodine on melted iron. We therefore state definitely that if Mr. Sherman is right, and if it is accordingly true that iodine either removes phosphorus from iron or renders it innocuous, then modern chemistry is all wrong. To assume, in the first place, that the small quantity of iodine used by Mr. Sherman can eliminate the phosphorus, is to assume an impossibility. Phosphorus exists in iron only as some one of the seven known phosphides of iron, all of which are extremely stable compounds. It is well known to chemists that the action of iodine on these compounds only differs from that of chlorine and fluorine in that it is less energetic, yet Hochstätter found the fusion of phosphides of iron with fluoride of calcium had no effect on them as regards the elimination of the phosphorus. Why, then, should iodine ? Iron may be dissolved in nascent chlorine obtained by decomposing hydrochloric acid with a battery, but the phosphide of iron and nickel contained in the iron is not decomposed; oxygen, we know, leaves the phosphides almost untouched. If, then, fluorine, chlorine, and oxygen are without effect—nay, even fail to manifest the smallest tendency to have an effect—why should we expect iodine to be active ? If at any temperature iodine should expel phosphorus, it must do so because of the superior affinity of the iodine over that of the phosphorus for iron; but this reaction could only take place after all the uncombined iron had been saturated with iodine. But such an event is impossible in the Sherman process, because the quantity of

iodine used is so small. As regards sulphur, much the same reasoning will hold good.

In point of fact, however, there is reason to believe that the iodine in the Sherman process does not remove all, or possibly any of the phosphorus, as the following analysis of one of the "blows" which we witnessed, and particulars of which we have already given, goes to show. The analysis was made by Mr. G. G. Barker, chemist to Sir John Brown and Co. :

Analysis of Bessemer Steel after being treated by Mr. Sherman's Process. Blow made with one ton of Glengarnock Pig Iron.

	Charge.	Steel after the spiegel has been added.
Combined carbon...	0.426	0.38
Graphite.....	2.419	Trace.
Silicon	3.08	Trace.
Phosphorus	0.104	0.045
Sulphur.....	0.09	Trace.
Manganese.....	0.592	0.625

The phosphorus is here reduced nearly one-half, but it is highly probable that a similar reduction would have taken place whether the iodide of potassium was or was not introduced, and as it is, quite enough remains to impair the quality of the steel if the element retains its normal activity. An analysis of steel iron made from common pig, gives the following results:

	Linthorpe.	Eglington.	Sondley.
Iron.....	99.450	99.34	99.51
Combined carbon.	0.10	0.13	0.12
Graphite.....	Trace.	Trace.	Trace.
Silicon.....	Trace.	Trace.	Trace.
Phosphorus	0.105	0.087	0.06
Sulphur.....	Trace.	Trace.	Trace.
Manganese.....	0.340	0.443	0.305

Sample of Cast Steel made from Linthorpe Steel-iron.

Combined carbon.....	0.910	Per cent.
Phosphorus.....	0.055	
Sulphur.....	Trace.	

Mr. Barker adds: "It appears, by comparing the rather large percentage of phosphorus with the mechanical results, that a portion of the phosphorus must be neutralized by Mr. Sherman's process," a very natural conclusion under the circumstances.

Seeing, then, that not only is it a physcal impossibility, according to existing chemical knowledge, for the iodine put into the converter or the puddling furnace, to eliminate the phosphorus, but that direct experiment proves that chemical knowledge is so far accurate, we find ourselves on the horns of a dilemma. That the iron treated by the Sherman process which we saw tested, was thereby improved, is, we think, if not clearly proved, still highly probable. The question then remains to be settled, to what is the improvement due? The phosphorus being there, why does it not operate for evil? The only answer is, that the element is in some way rendered innocuous. One explanation is that the phosphorus becomes amorphous or allotropic. That iodine will render phosphorus allotropic under certain circumstances is known, but the theory completely breaks down when applied to the Sherman process. Phosphorus will not remain amorphous at any temperature near that of molten iron; therefore, to imagine that it can retain a state of allotropism in the puddling furnace or the Bessemer converter is simply absurd.

There is one solution of the difficulty which we put forward as being much nearer the truth. It is that the iodine used by Mr. Sherman has no effect whatever. That, in a word, the whole virtue of the process lies in the potassium and not in the iodine contained in the mixture he uses. At the temperature present in the converter and the puddling furnace it is quite possible that all the iodine simply escapes as vapor, and that an alloy of iron and potassium is formed, which, reacting on the phosphide of iron, forms a phosphide of potassium that remains entangled in the metal, and does little harm. If this theory be correct, as good results will be obtained by blowing a few ounces of carbonate of potash through a Bessemer converter, as can be had from the use of the iodide of potassium used by Mr. Sherman, and the experiment is so simple that it is highly desirable it should be tried.

It is just possible, after all, that the laws known to apply when small quantities of metal are treated in the laboratory may become modified when larger masses of metal are dealt with, though this is unlikely. It is, we think, pretty evident at all events that the iron we saw made by

the Sherman process was better than chemistry would lead us to anticipate. We have definite statements, too, from the other side of the Atlantic, that fluorine is being used in the Henderson process—an account of which, by the author, we reproduce in another page—in the elimination of phosphorus with much success; yet, as we have seen, laboratory experiments go to show that fluorine can have no appreciable effect on phosphide of iron. It would be absurd to say that chemistry is a finite science, that its professors can never be at fault, and, therefore, that there is nothing in the Sherman process. All that we can say positively is that if Mr. Sherman is right, then chemists have a good deal to learn. That he is right so far as we have seen is apparently indisputable. It remains for us to watch the progress of the process, and see whether he will continue to be right. Neither Mr. Sherman nor any other individual living knows enough just at present about the chemistry of iron, to be justified in dogmatizing on the matter.

RIVERS: THEIR FUNCTIONS AND THEIR TREATMENT.

From "The Builder."

The universal diffusion of water is necessary to existence; and perhaps no process in the great economy of nature subserves more important and useful ends. The moisture evaporated from the ocean is carried inland, and the clouds, descending in rain, "drop fatness" upon the soil. This duty done, the configuration of the surface collects the drainage water in rivulets, the primary supply for the support of animal life; and the union of the latter in the lowest valleys produces the mighty stream, which, completing the rotation, returns the water to its parent sea.

It is no uncommon figure of speech to impute to great rivers the parentage of the dwellers on their banks; and our own familiar "Father Thames" readily occurs to the mind as an instance. Nor is the epithet undeserved; for in all times the great seats of population, industry, and wealth have been placed, for the most part, on the banks of a navigable stream. To the river, the city owed its existence, its protection from danger, its supply of the first necessaries of life, its communication, and its trade. The fairest and most stately buildings adorned its banks, and the highest and noblest denizens displayed their pomp upon its waters. The parent stream was held in affection, approaching personal regard; and in ancient times the feeling of veneration thus created has even led to its deification:

> "O Tiber, Father Tiber,
> To whom the Romans pray."

The great streams, as already stated, are formed by the union of many rivulets, and thus represent the result of the *drainage* of the entire district or watershed to which they appertain. The first function, therefore, of a river is the drainage of the land; and it is needless to dilate on the universality and importance of this duty. When, from either natural or artificial causes, it is inefficiently performed, the surface becomes moist or swampy, the atmosphere miasmatic and insalubrious, and the country more or less unfit for the habitation of man.

It has also been stated previously, that the great seats of population and trade have been usually placed upon navigable streams, to which, in fact, they owe their origin; and which form, also, the earliest, and in no few instances the most important highway of a country.

It follows, therefore, that the second great function of a river is to supply the means of internal navigation.

In considering, therefore, the treatment of rivers, with a view to their artificial improvement, these two functions, viz., drainage and navigation, have evidently to be kept in view: and almost all the works of river engineering have been directed to one or other, and not unfrequently to both together, of these objects.

It is proposed, accordingly, to discuss briefly in this paper the usual conditions found existing in large streams, from their point of discharge to their source; to describe the causes of impediment to the proper discharge of their functions;

and the best available means whereby such difficulties may be diminished or removed.

A frequent source of impediment to the navigation of rivers arises from the formation of bars at their mouths. This most usually occurs from the circumstance that the bed of the river is composed of soft material, which the running water removes and carries down with it in suspension to the sea. Then the flow of the stream being arrested, and its silt-bearing waters brought to a stand-still, in consequence of their impingement on the sea, the material in suspension subsides or settles down at that point, and forms a bar across the entrance of the river. As the greater or less velocity of the current will determine the distance to which it is carried out to sea before its flow or motion is sufficiently checked to allow the silt to deposit, so will the distance of the bar to seaward from the mouth of the river be regulated.

The first effect of this process is naturally to shoal the water or form a bar at the entrance of a navigable river, to an extent generally limited by the circumstance that the river water must at all times force its passage over or through the bar into the sea. Nor are the impediments to navigation always confined to such shoaling alone. When the mouth of the river is in an exposed situation, the bar is liable to become, as it were, an artificial foreshore, over which breakers are formed and roll with violence; and the depth of water on the bar is then further diminished by the extent to which the trough of the wave descends below the level of the smooth water. The surface of the water will, in such a case, frequently pass with great rapidity from a state of quiescence to one of agitation, and remain so for a lengthened period; detaining vessels, in many instances, for weeks together, from the impossibility of their crossing the bar with safety. In fact, many frightful shipwrecks have occurred in attempting such a passage with an insufficient depth of water to keep the vessel afloat at the lowest level; the ship being alternately lifted on the crest of the waves and lowered in their trough till her bottom strikes on the bar, when the pounding motion thus produced on the heavy mass of her hull almost instantly breaks her to pieces.

It has been stated that the diminution of the depth of water over a bar is generally limited by the circumstance that the river current must at all times force its passage either *over* or *through* the bar into the sea. The former of these conditions usually occurs and continues whilst the river waters are at their average volume and normal state; when the tendency of the bar is to shoal to the utmost limit, at the same time increasing its width or transverse section from the continual accumulation of deposit. The latter condition, on the other hand, takes place at the period of heavy floods, when the increased velocity and volume of the current tends to sweep away the previous accumulation and to remove the material of the bar further out into the deep sea water. The force of floods, therefore, when thus available, is the most potent agent for keeping open the navigation; and the usual object of engineering works in such a case is to confine the force of the flood within artificial boundaries or limits, and to direct or discharge it fully upon the bar; when from the expansion of the river-current or otherwise, that effect did not previously take place.

When the object of works of this nature is to remove an existing bar, they usually consist of two embankments or walls in continuation of the natural banks of the river, carried out seaward to such a distance as to prevent the diffusion of the flood water, and the consequent diminution of its force, before it impinges upon the bar. Perhaps one of the most interesting examples of works of this nature, which have been recently constructed, is that from the designs of Sir Charles Hartley, for maintaining a navigable depth through the bar of the Sulina mouth of the Danube, the particulars of which it is now proposed briefly to describe.

The shore of the Black Sea, at the point where the Sulina mouth of the Danube discharges into it, lies nearly north and south, and a littoral current of about a knot an hour flows from north to south along the coast. There are no tides in the Black Sea, but the level of the water along the shore is considerably influenced by the action of the wind, varying from 18 in. below the mean sea-level when the wind is from the west, or off the land, to 2 ft. above that level when the wind is

from the east, or off the sea. The Sulina branch of the Danube discharges at right angles into the sea, its navigable width being about 300 ft., and it discharges a quantity of water, varying from 4½ million cubic ft. per minute during times of greatest flood, to a little over half a million cubic ft. per minute during the dry season. The amount of deposit held in suspension by the river water during these times (from which deposits the bar is formed) varies from about 1 in. in the foot, or 1-12th during the flood, to about 1-40th during the dry season, of the cubic quantity of water in the river.

The phenomena of the formation of the bars are sufficiently curious. In ordinary seasons, the matter held in suspension by the river waters is precipitated near the shore, at a short distance seaward from the mouth of the river; and this effect, frequently continuing for months together, forms a regularly increasing bar across the entrance. At the time of high floods, however, the river waters having a greatly increased volume and velocity, force their way through the bar further out into the sea, removing it either wholly or partially into deeper water, and leaving the river entrance comparatively free from obstruction. But the flood waters themselves, which carry a greater quantity of matter in suspension, form bars in their turn farther from the shore, as well as of considerably greater magnitude. Also, if the flood be accompanied by a westerly wind coinciding in direction with it, and lowering the sea-level as already described, this bar will be formed still further out to sea, owing to the greater penetration of the river waters; while, on the other hand, if the wind be eastward, or contrary to the flow of the river, the level of the sea is raised as above mentioned, the velocity of the flood waters is more effectually checked, and the deposit of the matter in suspension takes place more rapidly, resulting in the formation of a bar nearer to the shore, and of greater magnitude than in the former case. On the subsidence of the flood, these deep-water bars are gradually lessened, or partially removed, by the littoral current, and the formation of bars near the shore from the ordinary river waters proceeds as before, until another flood again sweeps them out to sea.

It will be readily understood from this description, however, that the whole mass of the deposited material at the river mouth is continually on the increase, even though a navigable passage through it may be maintained either by natural or artificial means. The result is, in fact, a constant encroachment of the land upon the sea; and the delta of the River Danube, which discharges through no less than eleven mouths into the sea, has attained the dimensions of about 40 miles from east to west, and about 50 miles from north to south; and covers an area of considerably more than 1,000 square miles.

The system of improvement of the Sulina entrance recently adopted by the European Commission of the Danube is described by the engineer as being that of guiding "the river waters across the bar, by means of piers projected from the most advanced dry angles of the mouth; or, in other words, that of concentrating the strength of the river current on the bottom of the proposed seaward channel, by an artificial prolongation of the river banks into deep water." For this purpose, two piers were built out into the sea in continuation of the river banks, the northern pier being 4,631 ft. in length, and the southern pier 3,000 ft.; the formation of the shore allowing the south pier to be commenced at a considerable distance seaward of the shore end of the north pier, and the latter also projecting out somewhat further. These works had naturally the effect of concentrating the river current, and directing its whole force on the existing bar; and they have been carried out to such good purpose, that the navigable depth has been increased from 9 ft. to 17 ft., to the immense improvement of the navigation, and consequently of the trade of the locality.

It may be understood that in works of the above nature the effect is but temporary, as the deposit of silt ever continues, and that in a period of time varying according to the circumstances of the case, a further prolongation of the piers will become necessary; and this applies to all rivers carrying matter in suspension to the sea.

The above effects are considerably modified where a river discharges into a tidal sea. In this case, the river waters, instead of descending with a regular flow, are penned back, and rendered stationary by the rising or flood tide, and are therefore

liable during its continuance to deposit the matters held by them in suspension in the upper reaches of the river, instead of at its mouth. In general, however, the entrance of such a river is kept comparatively open by the tidal scour, especially when the ebb tide, uniting with the fresh waters, creates a strong downward current. Such a current is also less liable to be brought to a stand-still by impinging on the sea; as, instead of being arrested by the salt water, it continues its flow in conjunction with the retreating tide, to which its waters are united.

The above, however, though the most common, are not the only cause of the formation of bars. It also frequently happens that deposits are formed at the mouths of rivers by tidal silt-bearing waters which are checked in their regular flow at that point. The Thames is a notable example of this effect. The flowing tide runs along our eastern coast in a southerly direction from the north of Scotland to Essex, and the flowing tide through the English Channel runs at the same time in an easterly direction to beyond Dover, and, turning northward from this point, it meets the northern flow above mentioned.

These opposing currents arrest each other's velocity opposite the mouth of the Thames, and enormous deposits in consequence take place in the estuary into which the river discharges, though, fortunately for the navigation, the scour created by the tidal waters, passing into and out of the Thames itself, is sufficient to keep open several navigable channels at its mouth, where sufficient depth of water for the largest vessels is constantly maintained.

Again, in the Dornoch Frith, which is the most northern estuary on the east coast of Scotland, there is a remarkable example of the formation of a bar by tidal waters. The mouth or outlet of the frith forms a semicircular bay of considerable extent, the diameter of which is open to the sea; but at the upper end or head of the semicircle, the prolongation of the frith is contracted abruptly to about $\frac{1}{4}$ of that diameter, and it continues its course inland with that diminished width. The consequence is that the flowing tide from the open sea is guided along either shore of the semicircular bay till it gradually forms two littoral currents, which meet each other in opposite directions at the head of the bay, opposite the point where the frith is suddenly narrowed, as above explained. These littoral currents, thus meeting from opposite directions, bring each other to a comparative stand-still opposite the point where the upper or narrow portion of the frith discharges into the bay, where they deposit the silt which they carry in suspension. Thus the curious effect is produced of the formation of a bar opposite the mouth of the upper portion of the frith, but which is formed from the deposit of silt by the external waters of the sea, instead of by the internal waters of the river.

This effect, of course, ceases on the commencement of the ebb tide, when the current is turned in the opposite direction. The tendency of the ebb is to remove the newly-formed bar; but as there is only the water contained in the upper or narrow part of the estuary available for this purpose, which is considerably less in quantity than the flood setting in through the bay, the bar permanently continues. It is found, moreover, that the depth of water over the bar is greatest after the occurrence of heavy landfloods acting in conjunction with the ebb-tide.

A bar is also formed in the same locality, but from a different cause, at the sea entrance to Cromarty Frith, immediately south of the Frith of Dornoch, just referred to. This entrance consists of a narrow chasm between two lofty headlands, of about a mile and a half in length; on the landward side of the entrance the frith suddenly expands into a bay of several miles in extent. The tidal waters, in consequence, rush through the narrow passage with great velocity, and deposit their silt on either side of it when their velocity is checked. The flood-tide deposits its silt in the inner bay, and especially around its shores, where the velocity of the current is the least; and the ebb-tide deposits its silt at a short distance to seaward of the mouth of the narrow passage, forming a bar in a manner precisely similar to that of a silt-bearing river. In the latter case, the fact is observed, that the greatest amount of bar, and consequently the least depth of water over the bar, is found in the direction which is taken by the main current of the ebb-tide; the quantity of silt carried by

the ebb being, of course, the greatest in that direction.

The effect of the tidal waters in maintaining a navigable channel, either over a bar or through the deposits in the lower reaches of a river or estuary, is, in the majority of instances, of far greater importance than the effect of the river waters themselves. Any engineering works, therefore, in such a locality, whereby the tidal scour may be effected, usually require the most careful consideration ; and in the case of projected works in this country are made the subject of minute investigation by the public authorities.

Such works have generally one of the following objects in view, namely, to improve the navigation, to form lines of wharfs or quays, or to reclaim for cultivation the lands lying on the foreshore of the river or estuary, which were previously submerged at high water.

For maintaining the navigation, it is usually advisable to admit the greatest possible quantity of tidal water into the river. The reason of this is manifest. As the river approaches the sea, its inclination diminishes, until it becomes nearly or entirely horizontal, and the velocity of the upland waters is diminished in proportion. This causes them to deposit their sediment, and to diminish the depth for navigation. But the tidal waters, by creating what may be termed an artificial current, correct this tendency and keep the channel clear, and the larger the body of tidal water admitted into the river, the more effectually this duty is performed.

Though, however, it may be assumed as a rule that the larger the quantity of tidal water the better, yet this rule may admit of some exceptions. For instance, if any portion of a river subject to tidal influence be expanded to a considerable width, so as to form a sort of lake at that part, the tide during its flow will be partially occupied in filling this expanse, and proportionately prevented from rising or flowing into the portion of the river immediately above, which is thus deprived of the full advantage of the tidal scour. In such cases it may be more advisable to contract artificially the channel of the river to its normal dimensions, even though the capacity for receiving tidal water should be somewhat diminished. In short, the benefit of the tidal influence is measured, in one sense, by the cubical quantity of tidal water which the river receives ; and, in another, by the height or distance up the river to which the tide ascends, and the balance of greatest advantage is arrived at when due regard is paid to both considerations, either of which may predominate according to local circumstances and requirements.

The most successful results in the improvement of tidal rivers have been attained in many cases by simultaneously regulating the width of the channel and deepening the bed of the stream. The latter process may be effected in soft soils, such as the alluvial plains of India, by means of the river current itself, which when properly regulated, will scour its own channel to the required extent. But it frequently happens that river shoals acquire, in the course of time, such hardness and consistency that no improvement of the channel will suffice for their removal. In such a case, the principle usually adopted by engineers is to remove the cause of the formation of shoals by measures tending to increase the velocity of the current, and then to remove the shoals themselves by dredging. The latter process has the further advantage of increasing the capacity of the tidal channel, and of allowing the tide to flow freely in both directions, which has the effect of increasing both its height and depth. Dredging has accordingly been very extensively practised in navigable streams; and in the Thames alone it is stated that about ten millions of cubic yards have been thus removed from the bed of the river.

The usual means of regulating the width of rivers is by the construction of longitudinal or training walls on either bank. They are built, according to circumstances, of masonry, concrete, or timber piling, or formed by earth embankments pitched with stone where exposed to the running water. Such embankments are also frequently formed of alternate layers of earth and fascines, or bundles of faggots, which makes a cheap and good construction for rivers of moderate velocity. Where the space or foreshore to be reclaimed is very large, and the filling at the back of the training walls would consequently be expensive, it is usual in the first instance to run out timber groynes from the bank at intervals, about half-

tide high, across the space which it is proposed to reclaim. These constructions intercept and gradually collect between them a considerable portion of deposit from the river; and when this is done, the training walls are built. The most successful instance of a river improved in this manner is, perhaps, the Clyde at Glasgow, where the depth available for navigation at low water is stated to have been increased by the measures above-described judiciously applied, and by dredging, to no less an extent than from 2 ft. to 20 ft. These works, and the importance of the port resulting from them, are, perhaps, the greatest triumph on record in this branch of engineering.

In some cases, as in the Dee at Chester, groynes, as above described, have been applied without further constructions. But this treatment has been found to produce irregularities in the course of the stream, and, in fact, to be prejudicial to the improvement of navigable rivers rather than the contrary.

The above are the principal natural phenomena at and near the mouths of navigable rivers with which engineering skill and science have been required to deal. It is now proposed to proceed upwards, and review the causes of impediment to navigation and drainage which usually occur in the higher portions of streams.

It has been already stated that the lower reaches of rivers generally flow through a flat country, and consequently with a comparatively sluggish current; and this applies to the portion both within and immediately above the tidal influence. It is a curious natural fact that the tendency of a river under these circumstances is not to preserve a straight course, but to form for itself a winding or circuitous channel. The current, in the first instance, is probably deflected by some artificial obstruction, such as a partial hardness of the soil, from its straight and proper course, and cuts its channel in the direction of least resistance. The weight and force of the stream, instead of moving along the middle of the river, as they would do in a straight channel, are by this means directed sideways, so as to impinge on one or other of the banks, whence the stream is again deflected (like a billiard-ball striking obliquely upon its cushion), in an angle corresponding to the angle of incidence. This takes place in nature upon the largest scale; and the effect of these irregularities is, in many cases, surprisingly regular, forming a continuation of alternate or S bends, of equal curvature. Of this the Thames presents many notable examples, and the great rivers through the alluvial plains of India are often wonderfully regular in the form and extent of their sinuosities.

Where the river is of this nature, the outer or convex side of the curves or bends is naturally the deepest; and the inner side is liable to shoal. Between the bends the line of main current and of deepest water naturally sets across the river, from the outer curve on one side or bank, to the succeeding outer curve on the other.

It is evident from the above description that the current will tend continally to abrade or bite upon the outer curve or bank at these bends, and to deposit and shoal the course of the water at the inner curve. The continued abrasion in the former case also tends to widen the bed of the river, to diffuse the stream over a larger space, and to weaken its force in proportion.

The effect of such sinuosities is also to increase the length of the channel to a large extent, and to diminish its rate of fall in proportion, thus aggravating the evil of insufficient velocity to which rivers in flat countries are liable. These remarks are even more applicable to the reaches above the tidal influence than to those below it, as the volume of the river water, and its consequent capacity for maintaining a clear channel, are usually very much smaller than that of the tidal stream.

The straightening of bends, so as to form a direct and uniform channel, is of course the most obvious remedy for this evil; and it occasionally happens, when a bend is very circuitous, that a very short artificial channel will save a comparatively great distance in length of river. These operations, however, involve the necessity of many precautions to insure their efficiency. The inclination of the channel in the new work of course becomes greater as its length is diminished, and the velocity of the stream is proportionately increased, involving the probability that the bed of the new channel may be scoured to a much greater extent than that of

the old, and that the material so removed may be deposited in the lower portion of the stream, where the current resumes its original rate of flow. Moreover, at the lower junction of the new and steeper with the old flat channel, the increased velocity of the stream receives a sudden check; and the current will expend its force, unless efficient measures be taken to prevent it, in ploughing or tearing up the bottom at the point where its velocity is so checked, and in throwing up the excavated material beyond in a bank or bar across the river.

The scouring power exercised by a river on various soils is, of course, measured by the velocity of the water at the bottom, which, owing to friction, is much less than the surface velocity.

It may therefore be interesting to state the comparative surface and bottom velocities of rivers, and the effect of those velocities in scouring various soils.

Surface and Bottom Velocities in Feet per Minute.

Surface.	Bottom.	Surface.	Bottom.
20	5	260	192
40	16½	280	210
60	30	300	228
80	45	320	245
100	60	340	263
120	75	360	280
140	92	380	300
160	108	400	315
180	125	420	333
200	142	440	351
220	158	460	368
240	176	500	405

Effect of different Velocities of Water in Scouring various Soils.

15 ft	per minute will scour	fine clay.	
30 ft.	do.	do.	fine sand.
45 ft.	do.	do.	coarse sand.
60 ft.	do.	do.	fine gravel.
120 ft.	do.	do.	round shingle, 1 in. diameter.
180 ft.	do.	do.	angular stones as large as an egg.
300 ft.	do.	do.	conglomerate.

One of the most important points in the treatment of rivers is to ascertain their liability to be affected by, and to provide measures against, the destructive results of heavy floods.

The effect of floods is very variable in different rivers, according to local circumstances. It is more destructive when, owing to a retentive soil, to steep slopes on the sides of the valley, or to both in combination, the waters of heavy rains are collected rapidly in the river, so as to swell its volume beyond the capacity of its channel. These effects are modified, on the other hand, by an absorbent soil, or by a flat and extended valley, which retains the water, and obliges it to pass slowly to its natural outfall, thus enabling the discharge to be gradually effected. In this way the flooding of rivers has been aptly described as a race against time; though in the case of long-continued and heavy rains, when the surface and soil become fully saturated, the rainfall begins to flow into the river with almost equal rapidity in the latter as in the former case. But the most rapid and destructive inundations are caused by the melting of snow, and almost all the great rivers of Europe owe their highest floods to this cause.

The absorbent strata in this country are chiefly sand and gravel, chalk, limestone, and sandstone. The extent to which floods, as well as other conditions of a river, are modified by the prevalence of porous strata in its watershed, is well illustrated in the case of the Thames itself. The upper portion of this watershed consists, as is well known, of the chalk formation, which absorbs and stores the rainfall to a large extent, returning it to the river in dry weather by means of perennial springs. In consequence, the stream, excepting in long-continued rains, is uniform to a remarkable degree in the quantity of water it discharges; and its liability to flooding is caused much more by the artificial obstruction of weirs and mill-dams than by any natural condition attaching to the river.

As a rule, a flood commences when the strata, whatever they may be, are saturated with water so that their absorbent qualities are exhausted, and this is frequently exemplified by the circumstance, that a given amount of rain in summer is found to be disposed of by absorption and evaporation, and never reaches the river at all; while the same amount in winter, with a saturated atmosphere and soil, will pass into the river without diminution, and sometimes cause a flood.

The absorbent strata tend to moderate floods, not only in proportion to their porosity or capacity for containing water, but (especially in the case of limestones and sandstones) by the dip of their beds, which, particularly when of steep

inclination, facilitate the subterranean escape of the rainfall.

Again, the effects of a flood are moderated on a large scale in nature by the existence of lakes, which afford an extensive area for the storing or retention of flood-waters, and enable their contents to be discharged gradually and quietly by the outlet rivers at their lower extremities. Many instances of this kind may be referred to. The two great lakes which supply the source of the Nile are said to furnish to the upper portion of that river a remarkably uniform amount of water; and although the river receives directly the flood-waters of the districts below, which convey the well-known mud deposits of Egypt, yet the lakes referred to have the effect, on the whole, of moderating the flooding of the country to a material extent. On the continent of Europe also, the great lakes at the foot of the Alpine ranges, which receive the waters of the melting snows, serve the purpose of moderating the inundations, which, though still often destructive, would render the valleys below those lakes totally uninhabitable if their impetuous discharges were uncontrolled by this provision of nature.

The modification of floods by means of engineering works, is a matter of considerable difficulty. In some cases, as in the Po, dykes or artificial banks have been constructed for this purpose; but the tendency of the river to raise its bed by the deposit of the material carried down by the floods, has involved the necessity of constantly adding to the height of the dykes, until the river is raised above the level of the surrounding country, rendering any future escape of its torrent liable to be doubly destructive.

The French engineers have proposed, for moderating the floods of their great rivers, to form a system of artificial lakes at the mouths of the tributary streams, so that the main stream should not be suddenly surcharged. But the usual and perhaps the most feasible course is to regulate, deepen, and improve the bed of the river itself, and to remove artificial or natural impediments from it, to the utmost practicable extent.

In very many rivers, of which the Thames and Shannon are notable examples, a constant antagonism exists between the interests connected with the navigation and those connected with the drainage of the adjoining country. The former can only be maintained by the construction of weirs or dams, which keep up the water to an artificial height so as to give it depth for navigation, at the same time affording water-power at the overfalls for mills. With the drainage, however, the matter is reversed, as the impediments thus created to the flow of the stream render it impossible to carry off the flood waters with sufficient rapidity from the low-lying lands adjacent to it. It becomes a question, therefore, of the comparative value of the drainage, or of the navigation, to the district. Until the present generation the interests of the navigation have been generally preferred, but the great extension of railways throughout Great Britain has much deteriorated the value, both in a commercial and national sense, of river navigation; and the modern tendency of public policy is to remove all obstructions to the discharge of rivers, as far as it can be reasonably effected with regard to the important private interests which the former policy has created.

It appears, in short, that in the early history of a country rivers play a most important part in providing the means of internal communication; and the Mississippi and other great streams of the American continent readily occur in illustration. As civilization and wealth increase, however, the necessity for drainage is more felt, while superior and more rapid means of communication by railways become universal. The tendency in this case, therefore, is to confine the navigation to the lower portions, where seagoing vessels may be accommodated, and to devote the upper portions to their original purpose of the drainage of the country.

The line of longitudinal section of a river generally forms a concave curve, which, of course, is flat at the lower end and steep in inclination at the source. In the upper portion the water supply is generally limited, owing to the contracted watershed and steep inclination of the bed; but the storm-water for the same reason is delivered into the stream with great rapidity where the strata are composed of retentive soils. Such positions are especially favorable for the working of mills, and are generally so occupied to the utmost possible extent in this country.

It is pleasing to reflect that at no previous time in our history have the advantages afforded by our British rivers, whether in a commercial, agricultural, or sanitary point of view, been so highly appreciated as at present. The maintenance of their volume is jealously guarded; and the preservation of their purity from all pollution is being made the subject of the most minute scientific investigation and the most careful legislation. In these facts the lovers of nature and of progress may alike rejoice; for in no other natural objects than our flowing streams are the useful and beautiful more fully united.

ROLLING STOCK FOR NARROW GAUGE.

We extract the following from a letter from Mr. Robert Fairlie to "Engineering":

Fig. 1 is a view of a first-class carriage; it is 18 ft. 6 in. long, and 6 ft. 8 in. wide inside, and 6 ft. high, in three compartments, to seat six persons in each; the division space gives 26½ in. to each passenger; the compartments in length and width are equal to the best modern stock now running. The carriage complete weighs 3 tons 5 cwt., 1 ton 15 cwt. in the under frame, wheels, springs, etc., and 1 ton 10 cwt. in the body—giving a weight

Fig. 1.

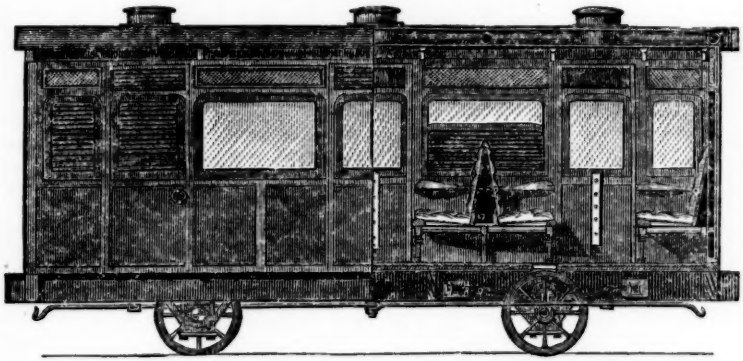
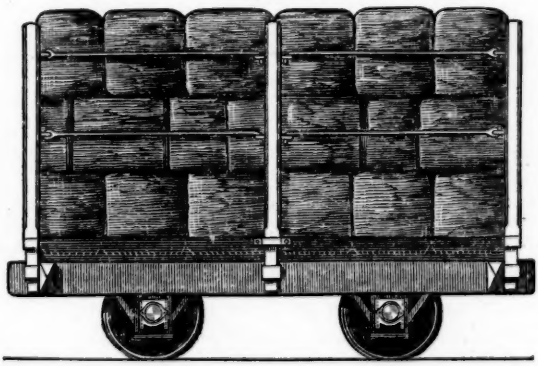
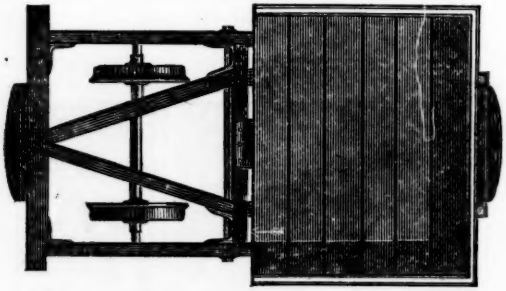


Fig. 2



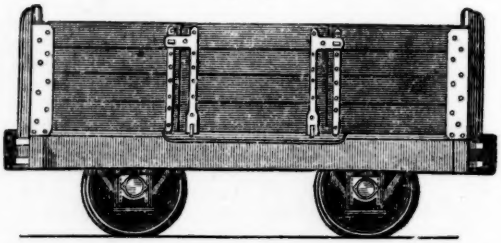
of 3.6 cwt. of carriage to each seat. The second class carriage is nearly similar, except, of course, the interior fittings. It is 16 ft. 6 in. long, and 6 ft. 8 in. wide inside, and 6 ft. high, to seat 8 in each compartment. The carriage complete weighs 3 tons, the under frame, with wheels, axles, and springs, 1 ton 14 cwt., and the body 1 ton 6 cwt., the proportion of carriage weight to passengers being 2.5 cwt. to one passenger. The third-class carriage is similar in size to the second-class, but accommodating five persons on a seat; the proportion of carriage weight to passengers is 2 cwt. to one passenger. The wheel base in the case of the first-class is 9 ft., and in the second only 8 ft. 6 in., so short as to permit the carriage passing a curve of 150 ft. radius with ease, yet it is so long compared to the gauge as to insure a perfectly steady-running vehicle. No buffers are used, but the circular end pieces of rubber faced with a thin steel plate, on my patent principle. The coupling rod is attached to the centre of the carriage frame, from which point it has a

FIG. 3.



radial movement. Fig. 2 represents a wagon to carry cotton in bales, according o the dimensions of the bales usually carried in India. The wagon is a plain, low-sided flat wagon, with six upright posts, having two round iron hinge rods between

FIG. 4.



each, which keep the bales in their place, and stay the posts. The wagon weighs 26 cwt., as follows:

	cwt.	qrs.	lbs.
Oak	5	0	16
Pine	5	2	22
Ironwork	15	0	18
	26	0	0

and carries 4 tons of cotton loaded, as shown; the floor area of the wagon is 6 ft. by 10 ft. 6 in., and carries exactly 24 bales, measuring about 12 cubic ft. each, and weighing 3.75 cwt., giving a proportion of carrying capacity of 3.3 to 1 of dead weight.

Figs. 3 and 4 represent a coal wagon; it is 10 ft. by 6 ft., and 2 ft. 10½ in. high in centre; at ends the cubic space is 160 ft., equal to 4 tons of coal. This wagon weighs:

	cwt.	qrs.	lbs.
Oak	5	0	16
Pine	6	0	27
Ironwork, springs, wheels, axles, etc...	17	1	21
	28	3	8

giving a proportion of a little under 3

tons carrying capacity to 1 of dead weight.

Fig. 5 represents a covered goods wagon; it measures 10 ft. by 6 ft. by 6 ft. high in centre inside, giving a cubic space of 360 ft.

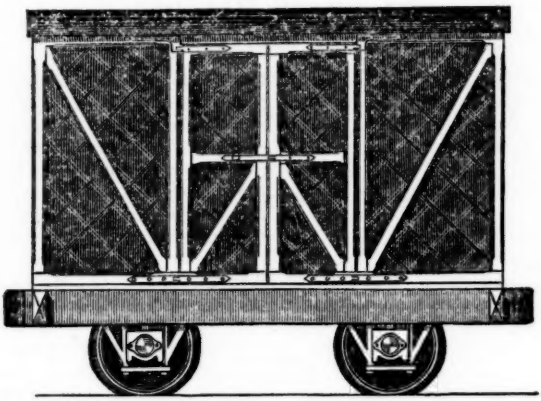
This wagon, of which but few would be required for groceries and special goods, weighs:

	cwt.	qrs.	lbs.
Oak	5	0	16
Yellow pine	12	1	13
Ironwork, springs, wheels, axles, etc...	15	0	27
	32	3	0

giving a proportion of 3 tons carrying capacity to 1 of dead weight, taking the capacity at 72 ft. to represent 1 ton.

The cotton wagons are intended to be covered by sheeting, and in this manner the cotton is perfectly protected, besides being much lighter. This class of wagon is very convenient for loading and unloading compared with covered wagons, and, as it may happen, should cotton take fire by spontaneous combustion, or by a stray spark (which is less likely to set fire to sheet covering than to a dry matchboard covering from the engine), the fact that it has done so is seen at once, and the bale or bales which have been ignited may be

Fig. 5.



tumbled off the wagon without much injury being done; this cannot be done with the covered wagons, the contents of which, when once on fire, may be destroyed before seen, and when perhaps it is too late to save others in the train. When there is no cotton to carry, the posts are removed, and a capital flat wagon is provided capable of carrying the heaviest field artillery, together with all the equipments as now used in modern warfare. The 4-ton cotton wagons have the spaces between the posts at sides and ends fitted with panels of match-boarding, a portable top with six legs can be added, fitting into sockets in the flooring, and a partition is fixed down the centre of the wagon, padded, if necessary, and you have the cotton wagon turned into a first-rate horse-box to carry two horses. The space for each horse would be about 2 ft. 8 in., after allowing for padding, the length of the wagon being 10 ft. 6 in., is ample so far as suitability of gauge for military operations is concerned. You have here a stock that would, on an emergency, move quite as much in the way of military trains as any prepared stock for the purpose on the 5 ft. 6 in. gauge. It is true horse-boxes on the 5 ft. 6 in. gauge will accommodate three horses in them; but, if they do, it is at the expense of weight. A horse-box to carry three horses on the 5 ft. 6 in. gauge will weigh 6 tons, whilst the extemporized horse-box out of the cotton wagon on the 3 ft. gauge would not weigh over 2 tons, with all the additions, and carry 2 horses; so that on the smaller gauge six horses would be carried for the same dead weight as on the 5 ft. 6 in. gauge.

The height of floor from rail is 2 ft. 6 in. There are no platforms required, as there are two steps on each side of the carriage running its whole length as shown.

The angle of stability is 38° both for carriages and laden cotton wagons.

It will be noticed that neither in the carriage nor wagon stock are any buffers used; the circular ends are composed of a block of timber under a cushion of india-rubber, which is faced both back and front with thin steel plates, by Sterne's patent process. The vehicles in each train are all coupled up so as to touch each other, and whether on curves or on the straight, this position is never changed. Each carriage or wagon in a train takes its own true position on the rails without reference to its preceding or following one, the whole being joined together in one continuous mass, but with so many joints, like the vertebræ of a snake. No one wagon need be strong enough to pull the whole train behind it, as is now the case with the ordinary coupling, consequently a large reduction can be made in the framing, and yet be of equal strength. By this system of coupling the accident which cost so many valuable lives at Harrow, a few weeks ago, could not have happened, because the driver of the engine cannot possibly jerk the wagons in his train as he can do now, and break every coupling in it if he chooses to do so.

ON WATER METERS.*

From "Journal of The Society of Arts."

The question of measuring water supply by meter has for a great many years been occupying the attention of engineers. Ever since 1824, a yearly increasing number of inventions bearing upon this important subject, and amounting at the present time to a total of 313, have been brought before the public, in which are included patents taken out in England and communications from foreign engineers which have been registered at the Patent Office; yet, with all this great expenditure of ingenuity, it is generally allowed that there is no meter at present in really practical use which may be considered an accurate, or, in any way, a satisfactory machine.

If we take a review of the time that has elapsed since 1824, when I stated the first patenting of a water meter is on record, we find that up to the year 1851, a period of 27 years, 30 different inventions had found their way into public notice; whilst during the 10 years succeeding, or up to 1861, no less than 90; and again, from 1861 to 1871, or the present time, 193. I do not mean to say that all these were for separate and entirely different machines; the larger proportion were so, but a great many only specify certain improvements in previous inventions, or apply them to particular uses, a process which frequently implies the production of a practically new instrument.

There could be no better argument than the above statistics found in proof of the general demand for a good water meter, since all invention is necessary the result of some extensive public requirement. We may also adduce the fact that, unsatisfactory as are all the meters at present supplied to the public, they have, at least, those amongst them which present fewest defects in working, meet with liberal customers among the water companies and private individuals, who are willing, at much personal inconvenience and expense, to refer the estimate of the supply of water to the arbitration of these meters. In large factories, for instance, or in the case of machinery driven by water or steam power, and large stabling establishments, hotels, and even the better descriptions of dwelling-houses, it has been found an advantageous arrangement, and examples are enumerated by advertisers of water meters, pointing out the benefits likely to accrue to their purchasers, either on one side or other of the meters, from their use. For instance, a sum of £40 per annum paid in one case for water, rose no less than £1,000 in favor of the suppliers, after the introduction of a meter. We may view the matter in another light, by comparing our dealings with water supply with our management of gas, not that the cases are in all respects similar, for gas is a luxury hardly yet a necessity of life, whereas pure, wholesome water is, in the truest sense of the word; but gas is, viewed scientifically, a very similar material to deal with, and is supplied by volume through pipes, and is turned on

* From a paper read before the Society of Arts by Mr. Frederick E. Bodkin.

and off as required, and measured and paid for by meter. Moreover, by comparison of equal volumes, we find that water is the more expensive commodity of the two, which is an additional argument favorable to the use of water-meters under certain conditions, even though there were more difficulty and expense in obtaining them.

If, instead of viewing the extreme cases I referred to above, we consider in a more extensive aspect the question whether the invention and use of a good water-meter would be advantageous to house-holders and other consumers alike, one cannot but feel that the present system adopted for the general public, of payment according to the ratal or means of each separate consumer, is a most wise and liberal arrangement, hanging the chief burden of expense on the wealthier classes, and supplying an equal necessary of life to the lower orders at greatly reduced cost. Nor would the introduction of meters necessarily relieve any particular class, since the same expenditure would have to be defrayed as our requirements of proper purity and supply at present entail on the several water companies, whilst it would certainly act very prejudicially to the appearance and health of the "great unwashed" of our large towns, who would be only too anxious to reduce their water bills to a minimum. Perhaps, however, with the introduction of constant supply, the general use of water-meters might become an advantage—almost a necessity—to prevent waste; but in London, where this would be most severely felt, constant supply is, as yet, only a very remote possibility.

There are also other uses to which water-meters may be applied, such as calculating the supply of water to steam-boilers, for the purpose of ascertaining their evaporative power; also the expensiveness generally of water and steam power, a means of accurately judging which would enable the engineer, with far greater facility, to arrive at their comparative excellences. The great difficulties which surround the designing of a good water-meter must excuse the ill success, so far, of inventors in meeting this demand; these may be better judged of by a short statement of some of the offices required of such a machine.

Firstly, a water-meter should register with accuracy, that is, within 1 per cent. of the truth; and this, it must be remembered, not under a uniform rate of flow of the fluid, but under every possible variation of pressure, from a head of only a few feet, up to 200 or 300, unless indeed it be intended to act as a low-pressure meter, to some of which I shall call attention presently, and also under any ordinary variations of temperature.

Secondly, it ought to be of sufficient strength throughout to stand these high pressures, and even sudden alterations and blows under them, which form a still more trying ordeal.

Thirdly, it is very requisite it should be cheap, both in original cost and to maintain in repair subsequently. This latter consideration is very important, as under high pressures any bearing surfaces would be travelling at a great speed, and, even with the common impurities of water, would be liable to wear away very fast.

Fourthly, simplicity, both in number and shaping of parts, chiefly because all water-meters are liable to get soon clogged with a muddy deposit, and require cleaning, and any complexity renders this operation difficult and expensive; it also naturally infers great costliness in repairs when the machine gets out of order, a defect to which such would be particularly liable.

It also often happens that a meter may be left unused for a time, and the working parts become dry. This should not interfere with the accurate working of the machine on its again coming into use; it is also greatly to the advantage of any meter that it should be uninjured by the entrance of heated water or steam, when supplying steam-boilers or other machinery, where such are used; that it should form a closed valve against the return of water already passed through it; also that the register and work should be out of reach of interference of people desirous to tamper with them; and a very important consideration, that there should be as little loss of head or decrease of flow as possible in the water during its passage through. There are also peculiar excellences, if we may believe the statements of advertisers, which recommend some meters for use in private dwellings, far in preference to others; for instance, a certain Frenchman, with the ardor of competition so peculiar to our neighbors, de-

scribes his invention as not only a perfect meter, but a useful and elegant ornament for a gentleman's hall or drawing-room.

When we come to consider more carefully the leading features of all this vast mass of invention, we find that it is mainly directed to the measurement of water, under two different conditions, low and high pressure; low-pressure where the water is delivered from the meter entirely free from momentum, and high-pressure where the water arrives at, passes through, and leaves the meter at the same, or nearly the same velocity. Low-pressure meters were in use some time before the introduction of the other description, are much more simple in design, and can be made to register with perfect accuracy; but they have now fallen into disuse, except in special cases, where a careful measurement generally of some fluid more valuable than water is required, irrespective of the time occupied in the process. It will be worth while to notice briefly the various ways in which this has been accomplished.

In the most simple method, graduated glass-tubes are used in connection with a barrel, or vat, or closed chamber, and by which the amount of fluid run off can be easily read. Another, almost as simple, consists in the use of a measure-chamber in connection with an ordinary tap; the tap is at one end, and a valve at the other, or feed end of the chamber. These are so connected that one turn of the tap handle allows the water access to the chamber, and closes the outlet; the reverse action closes the inlet valve, and allows the measured quantity to escape for use; each turn of the handle is registered. This principle is applied in many ways, some constructing the measure-chamber large enough for a considerable supply.

A third makes use of a large vessel of known capacity, generally an upright cylinder, and places a valve on a properly fitted seating at the lowest part; there are also floats in the vessel, and while the valve is closed and the water rising, the float also lifts, and in doing so actuates lever arms, which by ordinary mechanism shift the valves when the vessel is full, the lower valve from its seating, and a cut-off valve attached to the inlet pipe. One means whereby this is attained is by hanging a weight from the float over a pulley, fixing a cam on to the shaft of the pulley, and causing the cam to raise a long lever arm at one point of its revolution. As the arm rises and falls, it moves the valve. The float, when out of water, being heavier than the weight, fal's with the water and reverses the valves at the bottom; a register tells the number of rises and falls that have taken place.

A fourth group of inventions places two tanks side by side, or subdivides one by a central partition; in each are valves at the lower ends, and each contains a float. In one case a system of siphons is substituted, the supply-pipe is placed over the partition, and alternately made to direct its flow into one or the other subdivision; the floats rise in each alternately, and, in most cases, by a central axis, which they actuate by lever, change the direction of inlet, and raise their own outlet valves; the central axis has weighted arms attached, to insure the instantaneousness of the action.

According to another device, a subdivided trough is centred on trunnions, and caused to tilt or tumble over from one side to the other by the weight of water which has flowed into each division of it from a fixed inlet; the trough is generally made triangular in section, and so proportioned and centred that it shall not tilt until each division is quite full; the number of tumbles is registered in this case.

A further modification of the above arranges a number of these tumbling buckets round a centre spindle, their continual filling and tilting causing the spindle to rotate. Sometimes they are made to work in a water level, each bucket gradually sinking down to it. But when fixed, free to revolve, they are arranged so that each weight of water must overcome the resistance offered by an arm of a weighted lever, which comes in contact with a catch attached to each bucket, and will not allow it to pass until outweighted. The revolutions are registered, and represent in amount so many buckets full each.

A very novel idea is to measure, by means of a gas-meter of ordinary construction, the amount of air exhausted from any closed chamber, from which the liquid is allowed to run, the amount of water extracted being taken as equal to that of the air registered.

Endeavors have been made to convert

several of the above into high-pressure meters, by making them of sufficient strength, and causing them to work without loss of head by air compressed in suitable chambers.

From this brief account it will be readily understood that water can be measured by low-pressure meters with the greatest accuracy, but they are entirely useless for supplying large quantities at any speed. They always require the intervention of a cistern of some considerable capacity placed high up; and in large establishments a separate meter would be required for every cistern. They may, in fact, be considered quite inadequate to the requirements of modern water supply.

Among high-pressure meters a greater variety exists; they may be divided into two principal classes—those which give a positive registration of actual quantities of water, and those which register by inference from the flow or pressure of the water passing through them.

Amongst positive high-pressure meters, various arrangements of piston and cylinder hold the first place. The principle of these meters is, to inclose in a hollow, carefully bored cylinder of known capacity, a piston free to move from end to end by the pressure of the incoming fluid, the piston being caused by this force to drive out the quantities of fluid already measured. This motion, and its degree of perfection, will depend mainly on the arrangement of the valves which regulate the inlet and outlet of the liquid.

In the simplest form, the piston, very carefully packed, is fitted with a long piston-rod, protruding from a packing-box at one end of the cylinder, and bearing one or two catches, which, just as the piston reaches the top or bottom of its stroke, come into contact with or strike against the ends of levers, causing the valves to shift; or the same is effected by a roller on the piston-rod running up and down in a slot in a bar of metal, and striking each end in turn; the bar, on receiving the blow, throws over a weighted lever, which alters the valves; or, by some, a rack is used attached to the top of the piston-rod; this gears with a pinion on a fixed shaft, two catches are fixed on each side of the pinion, and these alternately throw over a weighted lever from side to side; the weight in falling turns a four-way cock. This last is a device used by Mr. Kennedy, in his patent water-meter, one of the first ever brought into use. It possessed the advantages over others of the same time, that it allowed a continuous stream of water to pass without serious loss of head, and registered very correctly. But the acknowledged defects of expense and great complexity, and also the continual attention required to keep it in working order, have caused its gradual fall into disuse, for it was found, as soon as the oil in the works, which are not in these meters in contact with the water, got thick, the tumbling-weight refused to fall, and the water passed through the half-open valve without registry; and fresh oiling was found necessary every few months.

Messrs. Chadwick and Frost, in their Manchester positive meter, cut a long flat strip off one side of the upper part of the piston-rod; against this flattened portion a roller is pressed to the end of a bent lever, the square ends of the strip or slot drive the other end of the lever at right angles to the piston-rod, causing it to actuate in that line of direction a valve, which allows the water to flow alternately through the connecting link to the back of two small circular discs; its pressure at once forces each forward in turn, carrying the main valve with it, thus forming a fluid pressure valve. This arrangement is found superior to Kennedy's meter, and in fact has gained the ascendency over all other cylinder meters we possess; but it is an expensive meter, and the number of wearing surfaces it contains prevent that durability which a high original expenditure ought to insure to customers. It will not either, without great additional outlay, stand exposure to heated water.

A French patentee specifies a long cylinder, containing two pistons joined by a rod, passing through a central division with bearings, on which the cylinder rocks, by the greater weight of fluid alternately in each end, the central bearing being hollow and arranged on the four-way cock principle, and opened and closed by the tilting of the cylinder.

A large number of meters have also been devised, with two or more cylinders as measuring vessels; these are fixed side by side, fitted with pistons, and their rods working a common shaft by means of cranks. By the revolution of this shaft,

two eccentrics or cams are made to open and close the valves ; these are sometimes placed between the cylinders, sometimes on the outside, and in one case, in a meter designed by Mr. Duncan, placed at considerable angle to the piston-rod. When the cylinders are placed in the same line, end to end, as in the case in some meters, the rod connecting the two pistons, by means of a long catch, is made to actuate bars placed parallel to the piston-rod and outside the cylinders. These bars move secondary valves, the primary valves being placed at right angles across the further ends of the cylinders, and driven by water pressure regulated by the secondary valves, thus forming a similar, but more clumsy, fluid pressure valve to that used by Messrs. Chadwick and Frost. In some cases the cylinders are made so as to slide telescopically on one common cylinder open at each end, with a central water-tight division ; but in this arrangement the valves are a great difficulty, and the accurate fitting of the cylinders is expensive.

When the cylinders are set at an angle to one another, it is generally, as in an invention of Mr. Jopling's, at right angles, and the piston-rod of one is made by direct action to open and close the valves of the other, the pair being enclosed in a water-tight casing.

An invention of Mr. Worthington's, of the United States, consists in an arrangement of two cylinders, each containing two plungers or pistons connected by a single rod, bearing a central division plate. The valves are placed between the containing cylinders, and the alternate spaces are connected by crossway passages, from one into the other of which the water flows before it leaves the meter.

The chief object aimed at by the combination of several cylinders is a continuous discharge from the meter, and the prevention of any concussion occurring in the pipes. This is so perfectly effected by Messrs Chadwick's meter, that any additional complication and expense, such as these machines involve, is quite needless.

Another American method uses a cork pis on or ram, packed with cupped leathers; and a Mr. Heppel furnishes a solid wooden cylinder, with an annular leather bag, and causes it to work loosely in a cylindrical casing. These have their advantages in cheapness and absence of friction, but their adaptability in continual contact with water is very questionable. The best form of piston for a water meter appears to be a cylinder of metal with a flange at each end, the intervening space being long enough to allow the travel of a rolling ring of india-rubber up and down during each stroke of the piston.

There is yet another combination of pistons and cylinders which has been devised for measuring water. The inventor places a number of cylinders round a central shaft free to revolve, and attaches the heads of their piston rods to the corners of an inclined plate centred on the central shaft; the pressure of the water against their pistons causes them to rotate, and their revolutions open and close their respective valves. They may also be placed along a common trough or pipe, and their piston-rods in gear with a common crank shaft. They are free to oscillate, and, in doing so, valves at their junction with the main pipe are alternately open to each side of a central partition in it, which divides outlet from inlet.

The next description of positive meters includes all which are constructed to work with flexible or elastic diaphragms. The principle of these meters is, that a perfectly water-tight partition shall be formed, capable of assimilating itself to either end of a containing chamber, its edges being firmly bedded in the sides of the chamber, so that water admitted on either side alternately will force the diaphragm tight against the other. The shape of the chambers used to enclose these diaphragms is generally those of a double sector, or a sphere, or with inclined sides and flat ends. The chambers are most usually broad and shallow, and made of two shaped plates bolted firmly together, with the diaphragm between them. This is made of leather or vulcanized india-rubber, toughened by layers of calico or prepared cloth. It is generally strengthened by a central plate of metal, to which a piston-rod is attached, which passes out of the chamber and actuates the valves.

In one patented by Mr. Ramsbottom, in 1855, there are two diaphragms in doubly conical chambers, the rods of which turn a common crank shaft. On this are two mitre wheels, which turn a rotary valve between them.

In a German meter, the rod actuates a lever with a chordal rack attached to the further end. This gears with a pinion, a crank on whose shaft moves the valves.

In another meter, four diaphragms are used at right angles, and all driving the same central shaft by means of cranks. From this shaft the registry is taken, and it is made to distribute through valves the supply of water to each pair in turn.

Meters of these descriptions will work with great accuracy, whilst the diaphragm remains entire. But it has been found impossible to discover any material which will endure active work with certainty; and, as soon as the smallest flaw occurs, water passes without registry.

Closely allied to meters of this description, are those whose measuring chambers are made of compressible bags or cylinders. One of the simpler forms of these was patented in 1850. It consists of a water-tight chamber, containing two compressible cylinders, distended with metal rings at intervals. Their upper ends rise and fall vertically as they fill and empty, raising and lowering each end of a bar with them. Chains from these ends pass over separate pulleys, and are attached to the ends of a cross handle of a four way cock. Another design fastens two such cylinders end to end on a rocking arm passing right through them. They rise and fall as they alternately increase and lose weight, and alter valves seated at their point of connection.

Compressible tubes have also been often suggested as water-meters; for use as such, they are wrapped round a centre cylindrical core, or coiled in a ring on a circular plate, and a pair or more of rollers, revolving round a shaft placed in the centre of the bag, and pressing tight against it, are caused to move by the pressure of the water entering one end of the bag, and forcing the rollers before it, in order to escape at the other extremity. By the time one roller has arrived at the end of the bag, a second comes into play; thus a series of waves of equal and known amount are continually passing through the bag, and being registered by the central shaft. An invention of Mr. Siemens makes use of a similar principle, by causing waves of liquid to pass down a tube of rectangular section, between the sides and a flexible central division. To all such meters the same objection holds as in the case of the diaphragm meter—that they are most uncertain in duration, especially if liable to stand idle, and their flexible portions to get dry and hard.

An entirely different description of meter are those which work on the principle of rotary force pumps or fans. They are usually made with cylinders or axes revolving either in the same centre or eccentrically in outer cylindrical casings with closed ends. The simplest form is that of a plate sliding in a hollow cylindrical shaft or an elliptical disc, sliding on a crank and revolving in an epicycloidal chamber, the inlet on one side, the outlet on the other. The fluid continues to flow and the ends of the plate or disc cut off equal quantities of fluid, and register the number of revolutions. Or the centre cylinder may be concentric with the outer casing, and have one or more flat vanes of metal let into slots in its periphery, which are forced into it at a certain part of its revolution, between the inlet and outlet holes, by a bulge or indent in the outer shell, causing the periphery of the inner cylinder to revolve in close contact with it, and forcing out the water included between any two of the vanes. These vanes are carefully packed and must revolve in close contact with the outer circle, and for the purpose of always keeping them tight against this, a cam is placed inside the inner hollow cylinder, which forces them out at all parts sufficiently,

A French invention proposes to shut up air in the inner cylinder, and trusts to its compression and expansion to keep them in gear.

According to another, an eccentric axle is fixed inside the inner cylinder with four short arms; on to these are hinged the travelling vanes, which at a certain part of the revolution, where required, bend at the hinges and recede, and afterwards again straighten and are forced forwards.

In these machines the accurate fitting and easy travel of the vanes is of great importance; but however carefully this may be carried out originally, from constant use these machines soon give signs of wearing, and neglect to register accurately.

Some inventors make use of oscillating vanes or pistons swinging round in hollow cylinders from one side to the other of a fixed partition, the inlet and outlet

being on each side and reversible by valves; and even more complicated arrangements of two or more swinging vanes, sometimes in adjoining cylinders, and other equally impracticable machines, have been proposed.

A great many adopt the method of hinged vanes or floats, capable of laying close alongside their centre spindle, and of spreading out against the encasing cylinder under pressure of water. After the principle of the fan, the vanes are made concave against the pressure of the water, and are hinged on to a cylinder, so made to revolve eccentrically, that just before it reaches the inlet opening, the blades are folded closely down, but on passing it they spread, and do not again close until they have passed the outlet.

Different arrangements of two cogged wheels, rolling in contact, have also been suggested; they are made of considerable breadth, and are placed in a double cylindrical casing, the one riding loose, the other fixed on a shaft which actuates the register. The teeth of such wheels must be very carefully made, in order to continue in contact at every instant of their revolution, the water being usually supplied immediately under the point of contact. It will be easily understood that the efficiency of the machine depends entirely on the good fitting of the gearing surfaces of the wheels, and which equally applies to the preceding description of meters, to the careful packing at each end of the drums. A meter which has not come into public use, but which has been found to work satisfactorily, when applied to measure the water supplied to steam boilers, consists of a string of ball fitting accurately in a loop formed in the supplying-pipe, and, passing over a pulley at each end, the water enters on one side of one pulley, and, carrying the string of balls before it, passes out at the other extremity. These balls cause the pulleys to revolve, and show how much water has passed.

Amongst inferential meters, which depend for their accuracy on their estimate of the velocity of the water passing through them, those which register the revolutions of an annular ring of metal, fitted with floats or paddles round its periphery, are most numerous; the water in this case being admitted through apertures, as nearly as possible at right angles to the surface of the floats, impinges against them and causes revolution in a very irregular proportion to the speed and pressure of the water. An invention of Mr. Ramsbottom's has been used to some extent, and consists of a wheel with radial floats. Another machine, by Mr. Taylor, is very similar. He uses a horizontal wheel, provided round the periphery with radial floats, and riding on a vertical spindle in a closed chamber. It is to be made of any material of the same specific gravity as water, in order to reduce friction on the bearings, and is driven by the water admitted through small holes close to the wheel. This meter has been used considerably in the North of England, but is found much inferior in correctness and power of discharge to others.

To insure an even flow, which was the only condition under which these meters would work accurately, and to prevent low pressure water from passing at all, several different methods have been devised. By one arrangement, the water is required to raise a clack-valve, held down to its seat by a delicate spring, before it can impinge against the drum; by another, the water is caused to pass through a contracted elastic orifice; and by a third means, the flow of water in its action on the drum is regulated by a specially designed governor.

The next class of inference meters include all those which register the rotations of drums with screw blades fixed round them. These drums are fitted into long cylindrical casings, and the water flows past them, having been first directed through fixed guides turning in the opposite direction, and causing it to impinge on the drum-blades at nearly right angles. An earlier invention of Mr. Siemens is of this description, who uses two drums, or two pairs of drums, turning in opposite directions, and set end to end in the same tube. The drums are made hollow, of a peculiar alloy, and have eight perfect screw threads passed round each. The registration is taken off the central ends of the drum shaft by means of mitre wheels, and there are directing guides equal in number, but exactly opposite in direction between each.

A patentee of 1851 places a similar drum, but rather longer, on a valve seating in a vertical pipe; it is thus rendered

capable of lifting before any impurity which may be carried along with the water. Some others use a great many series of drums and guides, and occasionally choose to admit the water without guides simply between two reversed drums on the same spindle. The accuracy of these machines depends largely on the careful fitting and balancing of the drums, and their continuing to work without friction; but even under the most favorable circumstances, they will not register with sufficient correctness at varying pressures, the error generally tending towards insufficiency at low pressures, and rising above the real amount at moderately high ones.

A further improvement has been suggested and used by Mr. Siemens and others, on the principle of a Barker's mill, whereby the water is admitted into the interior of a chamber fixed on a spindle, out of which it flows by means of bent or curved hollow arms; the reaction of the outflowing liquid (for the vessel is entirely under water) causes it to rotate in an opposite direction; the spindle moves on a steel pivot encased in a water-tight oil-chamber; the water is admitted through a dirt-box; the revolving chamber is furnished with retarding vanes, and the upper end of the shaft has a worm-wheel attached, which works the register.

The above metre has found most favor before the public, both in England and abroad, of all the metres yet introduced; but notwithstanding its superiority, it possesses many defects. It is expensive, and is not by any means certainly correct under all pressures; it is, besides, so very delicate, that it continually requires inspection and repair. It will pass water through at low pressures with a very insufficient registry, and will work backwards without difficulty.

A great step in the removal of all the above defects, both in this and every other meter yet introduced, is exemplified in an invention by Messrs. Cook and Watson, a metre which has only lately come before the public notice. It consists of an upper plate, indented on the under side with a ring of thumb holes, and riding loosely in a chamber over a lower plate, through which inclined inlet holes are bored. The water rises through these holes, raises the upper disc, and acting against the square ends of the thumb-holes, causes it to rotate at the same time. This action of course requires some small power to commence, but as soon as the upper plate is lifted it must also necessarily rotate. When the supply ceases the upper plate falls, and forms a tight valve against the return of the water; and since during its period of revolution this plate floats in a film of incoming water, there are no wearing surfaces involved in the machine. Small stays are placed on the upper surface of the revolving plate, in order to produce regularity of motion under varying pressures, and appear, from the specimens I have at different times been enabled to test, to do so with complete success.

These machines are not expensive, and offer but small opposition to the flow of the liquid, and certainly appear to be the simplest and most practicable form of high pressure meter yet invented.

A very different description of inferential meter consists in the use of a rod of alabaster, or other slowly soluble material, encased in a glass rod graduated, and at its lower end in contact with the running water. It is kept pressed down, and as it dissolves, the top descends and is supposed to denote the quantity of water which has passed. This seems very simple, but the readings must often be liable to considerable variation.

Russian Railways.—It is stated from St. Petersburg that the Russian Government proposes to concede 6,000 versts of new railways. In the course of the current year these concessions will be granted to the extent of 2,000 versts, either to companies or to private individuals. This is all very well, but Russia cannot be warlike and industrial at the same time; if she is warlike, she will not collect much foreign capital to assist her in the construction of railways.

Mints in Nevada.—The branch mint at Carson City, Nevada, is already a success. Not quite a year in existence, it does quite a large and increasing business in coining and refining.

The late reports from the Suez Canal encourage hopes of its financial success.

LIMES AND CEMENTS.*

From "The Building News."

Mr. Hunt commenced his paper by a reference to the causes which act in giving some limes the power of setting under water. He observed that Smeaton, when engaged in the construction of the Eddystone lighthouse, found that all limes that set under water were obtained from the calcination of limestones which contained a portion of clay in their composition, and his experiments led him to use a cement composed of Aberthaw lime and of Pozzolano. That Smeaton was right in the selection of his stones was almost certain, though perhaps he did not quite recognize the important part which the presence of clay (or silica and alumina in chemical combination) had in the result which he obtained. Referring to some tables exhibited on the walls, containing analyses of the best hydraulic limes, Mr. Hunt observed that such limes almost all possessed the same bodies, though in varied proportions. Limestones or calcareous stones (or those stones containing carbonate of lime) are of very various natures. There are, for instance, pure carbonates of lime (some of which are perfectly crystalline, as marbles), and others which contain, in addition to the carbonate of lime, magnesia, oxide of iron, manganese, silica, and alumina. The name limestone is generally applied to those stones containing at least 50 per cent. of carbonate of lime. A mere chemical analysis of a sample does not always give the results that are obtained by practice. Experience alone is the best guide in this matter. The existence of carbonate of lime in stones is easily detected by the application of dilute nitric or muriatic acid ; by the effervescence which takes place, caused by the escape of the carbonic acid gas from the carbonate of lime, pure lime is left behind. The next most important substance which enters into the composition of limestones is silica, which exists very nearly in a state of purity in flints, common quartz, agate, etc. It is not sensibly soluble in water or dilute acid, but dissolves freely in alkaline solutions at a temperature of from 300 deg. to 400 deg. Fahr. The next and last substance that plays any important part in limestones is alumina, which is recognizable in the form of common clay, but not then in a pure state, but in chemical combination with silica. None of the other bodies, except magnesia, are of any value as regards the hydraulicity of the lime. Chemical analysis shows that the stones which contain only from 1 to 6 per cent. of silica, alumina, magnesia, iron, etc., either separately or in combination, give rich limes upon being burnt. Limestones containing insoluble silica in the shape of sand, magnesia, oxides of iron, and manganese, but limited to between 15 and 30 per cent. of the whole mass, yield poor limes. Limestones containing silica in combination with alumina, magnesia, and traces of oxide of iron and manganese in various respective proportions, but within the limits of from 8 to 12 per cent. of the whole mass, yield moderately hydraulic limes. When the foregoing ingredients are present in the proportion of from 15 to 18 per cent., but the silica in its soluble form, the limestones yield an hydraulic lime. When the limestone contains more than 20 and up to 30 per cent. of these ingredients, an eminently hydraulic lime is yielded. Limes owe their hydraulicity to the presence of a certain quantity of clay, and sometimes, though rarely, to that of a certain quantity of soluble silica. It is supposed that during the calcination, silicates of lime and alumina are formed, with an excess of lime ; these, in slaking, absorb a quantity of water, and solidify in combining therewith, and the double salt being insoluble in water, the compound remains therein without decomposing, or at least only yields that small excess of lime which might have existed in the combination. Rich limes are the purest limes we possess, and the purer the carbonate of lime from which they are obtained, the more distinct are the appearances from which they take their name. These are, that they augment in volume to twice their original bulk (or more) when slaked in the usual manner. If employed by themselves without any admixture of foreign substances, their consistency is the same after many years of immersion as on the first day. Poor

* From a paper read by Mr. H. E. Hunt before the Civil and Mechanical Engineers Society.

limes do not augment in bulk at all, or only do so to a very trifling extent when slaked. They do not harden under water more than rich limes, and are acted upon by that agent in nearly the same manner. The middlingly-hydraulic limes set under water after from 15 to 20 days' immersion, and continue to harden for some time afterwards, but the progress of their hardening diminishes after the sixth or eighth month; after a year their consistence is equal to that of dry soap. The change of bulk they undergo in slaking is about the same as that of the poor limes. Hydraulic limes set after from six to eight days' immersion, and continue to harden; the process of solidification may extend over twelve months, although the greater part is completed by the end of the first six. Eminently hydraulic limes set within the third or fourth day of their immersion. After a month they are quite hard, and capable of resisting the dissolvent action of running water. No limestones are capable of producing, in a commercially valuable form, hydraulic limes unless silica be present in combination with alumina. All experiments go to show that, in proportions cited, it is the most efficient agent in producing the hydraulicity. Mr. Hunt next proceeded to speak of the calcination of limes, after which he enumerated and described some of the best known hydraulic limes of the country. Firstly, he named the Aberthaw lime, the chemical analysis of which is as follows: Carbonate of lime, 72.91; alumina, 7.18; silica, 10.74; oxide of iron, 1.77; moisture, etc., 7.40 = 100.00. The best proportions for hydraulic mortar are from 2 to 3 parts of sharp sand to 1 of lime. If the lime be used for concrete, 6 parts of shingle, or even more, may be used. When the lime is used for concrete under water, it should be mixed up for some hours prior to its being placed in the foundations. It usually requires a day to be set under water. This lime was used by Smeaton for the Eddystone lighthouse. The price, delivered in London, is 22s. 6d. per ton. Another powerful hydraulic lime is that made from the Halkin Mountain limestone, and which was exclusively used by Jesse Hartley, in the construction of the Liverpool docks. The analysis of this limestone is: Silica, 21.56; carbonate of magnesia, 80; alumina, 1.16; oxide of iron, .50; carbonate of lime, 72.60; water, etc., 3.38 = 100.00. This lime has very great power of setting under water. In rubble masonry and backing up for dock walls, the proportions are: 1 part of lime, 2 of sand, and ¼ of smithy ashes, ground for twenty minutes. The best mortar for foundations, sewer bottoms, pointing, etc, is made up of 1 part of lime, ¾ of sand, and ¼ of ashes, ground forty minutes. The most extensively used hydraulic lime of all, however, is the blue lias. Its chemical analysis is: Lime, 45.50; alumina and silica, 18.50; carbonic acid, 31.50; water, 4.5 = 100.00. The best quality in this large bed is to be obtained from the quarries in Warwick. The best proportions of lime to gravel, for concrete, are 6 to 1 if the gravel is good, and in ordinary weather; for mortar, 2 or 2½ to 1. The mortar is not of itself sufficiently hydraulic to set under water, but if allowed to remain for 24 hours, the water has no effect upon it whatever.

In the discussion which followed the reading of Mr. Hunt's paper,

Mr. C. H. Whitaker, who had conducted a large series of Government experiments for Mr. Grant, exhibited some very interesting tabular diagrams, and gave to the meeting an explanation of the objects sought to be attained in each experiment, and the mode of conducting them, with the deductions he had arrived at from the results obtained. Mr. Whitaker said that Mr. Grant's tables (published in the "Minutes of the Proceedings of the Institution of Civil Engineers") showed that the tests of strength of neat cement and of cement and sand proceeded very regularly and in the same increasing ratio from one day to one year or more. At from one to two years, Portland cement appeared to attain its maximum strength, at which it continued to remain without either increase or diminution. Portland cement gauged in a mortar-mill for half an hour with the expectation of a higher result than from ordinary hand-gauging (on account of the more probable intimacy of the mixture of the cement and water) showed the cement, however, to set hard, but very brittle, the highest test being less than half that of the same cement gauged at the same time by hand. Mr. Whitaker suggested to Portland cement manufacturers whether it would not be possible

to make cement of two different qualities — the one such as we know, hard, and capable of great sustained pressure, like cast-iron for instance; the other not, perhaps, capable of bearing so high a test of the ordinary kind as the first, but, being of a somewhat elastic nature, able to sustain a sudden blow (as wrought-iron), such as the impact of a wave; and, further, whether it was not probable that cement of this kind (though according to the present system of testing not so good) would be better suited to marine works, breakwaters, and similar structures. With regard to the adhesive power of different kinds of bricks with cement, those bricks whose porosity was the greatest, were (as might be imagined), as a general rule, found to hold the cement best. Stock bricks, undoubtedly, had the greatest power of adhesion to cement, but being more friable, broke at a point lower than that arrived at with some of the denser bricks, such as the Suffolks, Fareham reds, etc.; one brick of either of each sort would readily absorb 1 lb. of water. In each of these cases it was the brick itself which most often gave way, particularly the stocks. But as it was the *bricks* and not the *joints* which were broken and registered when this kind of fracture occurred, the relative adhesive value of each was not obtained, though it appeared to him most probable and most reasonable that the stocks would stand highest. There was no better brick for making sound work, especially in water-work, underground, or in damp situations. The experiments he had conducted tended to show that the stock-bricks bedded in cement set 18 per cent. stronger in water than in air, whilst all the other kinds, except some of the Galt bricks, set better in air than in water. He was not able to give the meeting any information as to the setting of *limes in water;* but a mortar composed of one part of blue lias or Dorking lime, and two parts of sand, seemed to be of about an equal strength with Portland cement compo, made in the proportion of 3 to 1. With regard to different kinds of Portland cement concrete, various materials had been tried, as broken glass, flints, pottery, Portland stone, and granite, as well as ordinary river ballast. The blocks were made of two different sizes, viz., 12 in. cubes, and 6 in. cubes, one set of each being kept in water, and another set in air for one year, when they were tested by crushing in a hydraulic press. The Portland stone concrete gave uniformly the highest results, that made in the proportion of 6 to 1, breaking at a pressure of nearly 1 ton per sq. in. The sharp angular pottery and broken flints were the next highest in the scale. The granite did not come out so well, and the ballast showed the lowest breaking strain of all, giving an average test (at 6 to 1) of about 0.60 ton per sq. in. The broken Portland stone appeared to be completely incorporated with the Portland cement, the whole becoming one homogeneous mass, the stones not tearing away from the cement when broken, but the entire block crushing together through stones and cement alike. The rough biscuit-like edges of the broken pottery gave to that material a similar character to the Portland stone, though in a less degree, and the sharp angularities of the flints, with their rough calcareous portions, gave to the concrete made with them the strength it was found to possess. The granite concrete appeared to have a tendency to crumble somewhat, and the round pebbly nature of the ballast giving the cement less hold on the particles of stone seemed to be the cause of its sustaining a less load than the other concretes experimented upon. Of a large number of tests of ballast concrete (being that most generally used), the strength varied most uniformly, according to the proportion of cement employed. One interesting fact which came out was that the larger cubes (12 in.) set in water stood a greater weight than those set in air, but the small blocks (6 in.) were stronger set in air than in water. It was suggested that concrete made dense by compression would stand a greater pressure than that made in the ordinary way. With this view duplicate sets were made similar to the others in every respect, with the exception that the materials were rammed into the moulds by hand-beating with a mallet, getting thereby more material into a cubic foot than when only thrown in and left to settle in the ordinary manner. The result showed that these blocks formed by compression broke at an average of 30 per cent. greater strain than ordinary concrete, leading one to infer that, could a still

greater pressure be applied, and greater density thereby obtained, a still higher result would follow. Mr. Whitaker said that Portland cement was undoubtedly the best for joints in any case, but that in tide-work, or where only a short time elapsed between the bedding of the bricks or stones employed, it was a good plan to strike the Portland cement joints as usual, and then point them on their extreme outside with a thin layer of Roman cement, which, setting immediately, would protect the Portland cement joint until it was completely set and needed no further aid from the Roman cement, which might wash off at leisure.

THE RESISTANCE OF FLUIDS.

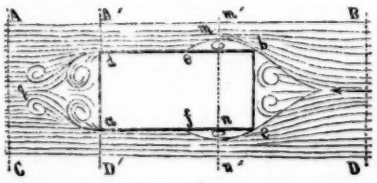
Translated from "Sonnet's Dictionnaire des Mathematiques Appliquées."

The resistance of fluids, except in a few cases, which will be considered hereafter, may be assumed as the same, for a body in motion in a fluid at rest, or for a body at rest in a fluid in motion, or for a body moving in a moving fluid.

THE RESISTANCE OF WATER.

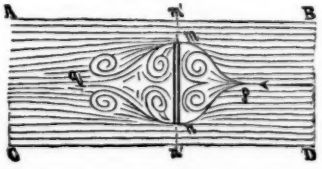
I. Let us first suppose that this acts upon a body entirely submerged in water. A striking complexity of motions is observed in the movement of water acting upon a solid body at rest, as shown by colored particles of dust suspended in the fluid. Let a plane, *mn*, rest in a fluid moving uniformly in the direction of the arrow (Fig. 1). The liquid molecules separate at some distance in front of the plane, diverge, and move in a lateral di-

FIG. 1.



rection; after passing the plane they converge, and finally resume their original parallelism. At the same time, in a certain space, *mpn*, in front of the plane, and in a space, *mqn*, behind it, there are fluid molecules which are affected only by gyratory motions. Similar movements are observed beyond the space *mqn*, caused by molecules flowing from *mm'* and *nn'*, to fill the wider space, AC. If the body is of the form of prism, or a cylinder (Fig. 2), *abcd*, being a section through the axis, the liquid particles, as in the first example, begin to separate at a certain distance in front of the body, and continue to diverge beyond the anterior face, *bc*, until they have reached a section, *mm' nn'*, where they become parallel, then they converge towards the sides of the body, and run parallel to it as far as

FIG. 2.



the posterior face *ad*; here they converge, and at a certain distance beyond *ad*, they resume their parallel motion. In all the intervals, *bpc*, *bme*, *cnf*, *aqd*, there are particles having gyratory movements. The same phenomena occur when a solid body moves in a fluid at rest.

If the body has a rounded end, such spaces as *mpn* (Fig. 1), or *bpc* (Fig. 2), which contain the gyratory particles, become smaller, and even disappear, if the form admits. This holds for either end. If the body is simply prismatic or cylindric, the spaces *mpn* or *bpc* form a kind of liquid *bow*, which accompanies the body in its motion, while *mqn* and *aqd* form a liquid *stern*. The circumstances described hold for all sections along the axis; for vertical as well as horizontal sections.

The complication of these phenomena forbids us to expect that they can ever be submitted to a rigorous analysis, so that an exact expression for the resistance can be obtained. But attempts have often been made to obtain an approximate expression for this resistance. Newton, in his "Principia," has given two theories, one of which, adopted by most authors, is a follows: Let *m* be a body

having a uniform motion of translation, with the velocity V in a fluid at rest; let m' be its position at the end of the time, t. Each point of the body will have passed through a space Vt, and the body will have generated a volume equal to that of the circumscribed cylinder, whose length is Vt. If A is the area of a right section, this volume is AVt The body has, therefore, displaced a collection of models of volume, AVt, imparting to them a velocity V. The total living force of the displaced molecules is:

$$\tfrac{1}{2}\frac{W A V t}{g} V^2,$$

W being the weight of a cubic metre of the fluid. The molecules must have received a pressure where work is equivalent to that of the living force. If R is this pressure its work is R. Vt; we have then

$$R \cdot V t = \tfrac{1}{2}\frac{W A V t}{g} \cdot V^2,$$

$$\therefore R = W A \cdot \frac{V^2}{2g}.$$

This measure is evidently that of the equal and opposed resistance which the body has received from the liquid. It is equivalent to the weight of a cylinder of liquid having for base the section of the circumscribed cylinder, and for height, the height due to the velocity.

II. Modern authors have attempted to determine the resistance by more profound investigations. Mr. Belanger has treated in a complete manner the case of a cylindrical body placed in the interior of a pipe, supposing the length of the cylinder to be at least three times its diameter. Let S be the transverse section of the pipe A B C D (Fig. 2),

A, the right section of the cylinder $a\ b\ c\ d$.
V, the velocity of the current in A C and B D.
V', the velocity in the annular section $m\ m'$, $n\ n'$, which we designate by S'.
V'', the velocity in the annular section a A', d D' which designate by S''.
P_1, P_2, P', P'', the pressures per meter in the sections B D, A C, S' and S''.
R, the resistance opposed by the cylinder to the motion of the liquid.

The motion being permanent, consider the portion of the fluid comprised between the sections B D and A C. The total quantity of motion remains constant, and consequently the sum of the total impulsions of the forces applied to it is zero.

Hence

$$R + P_2 S - P_1 S = 0$$
$$\therefore R = S(P_1 - P_2) \qquad (1.)$$

Considering the portion of fluid comprised between the sections B D and S'; as the fluid experiences no sudden variation, we have by Bernouilli's theorem,

$$\frac{P_1}{W} - \frac{P'}{W} = \frac{V'^2}{2g} - \frac{V^2}{2g} \qquad (2.)$$

Passing from the section S' to the section S'' the fluid experiences a sudden enlargement, and Bernouilli's theorem is modified. We must add to the second member the height due to the difference of velocities; giving

$$\frac{P'}{W} - \frac{P''}{W} = \frac{V''^2}{2g} - \frac{V'^2}{2g} + \frac{(V'-V'')^2}{2g} \qquad (3.)$$

From section S'' to section A C for like reasons,

$$\frac{P''}{W} - \frac{P_2}{W} = \frac{V^2}{2g} = \frac{V''^2}{2g} + \frac{(V''-V)^2}{2g} \qquad (4.)$$

Adding member to member (2), (3), and (4),

$$\frac{P_1}{W} - \frac{P_2}{W} = \frac{(V'-V'')^2}{2g} + \frac{(V''-V)^2}{2g} \qquad (5.)$$

and substituting in (1)

$$R = W S \cdot \left[\frac{(V'-V'')^2}{2g} + \frac{(V''-V)^2}{2g}\right]$$

But, on account of the incompressibility of the liquid, we have the relations

$$S V = S' V = S'' V$$

or

$$S V = m(S-A) V' = (S-A) V'' \qquad (6.)$$

m being the coefficient of contraction relative to the diminution of the section of the liquid in passing from bb', cc', to mm', nn'. Substituting the values V' and V'' determined by these relations, we have

$$R = W S \frac{V^2}{2g}\left[S^2 \cdot \frac{\left(\frac{1}{m} - 1\right)^2}{(S-A)^2} + \frac{S^2}{(S-A)^2}\right]$$

or putting $S = A\ n$

$$R = W A \frac{V^2}{2g} \cdot \frac{n}{(n-1)^2}\left[n^2\left(\frac{1}{m} - 1\right)^2 + 1\right]$$

an expression which is of the form

$$R = k W A \cdot \frac{V^2}{2g}$$

which is of the same form as the formula given by elevation.

M. Belanger has obtained analogous formulas by considering the case of a small disc, or a disc with a rounded prow. Mr. Poncelet, in a memoir at the close of his "Introduction a la Mecanique Industrielle," has arrived at the same results

by applying directly the principle of mechanical work; and he has extended these results to the case in which the body moves in a medium of indefinite extent, hypothesis that in this case the influence of the movement of the body extends only to a certain distance, and that it may therefore be regarded as placed in a canal limited in the transverse direction. The considerations in the case of a conduit then become applicable.

These diverse theoretical investigations lead to the conclusion that the resistance opposed by a fluid to the relative motion of a body is in all cases proportional to the square of the relative velocity. Most authors since Newton have admitted this.

When the velocity is oblique to a plane surface, it is admitted that the resistance is proportional to the square of the normal component of this velocity, so that if i denotes the inclination, the resistance is

$$R = k \cdot WA \cdot \frac{V^2 \operatorname{Sin}^2 i}{2g};$$

that is, it is proportional to the density of the fluid to the area of the surface impinged upon, and to the square of the sine of the inclination.

But this law holds only when the length of the body is inconsiderable with reference to the transverse dimensions. For as the length increases, it becomes necessary to take into account the lateral friction along the sides. Coulomb was the first to show that the formula for this friction should contain two terms, one proportional to the square of the velocity and expressing the loss of living force due to the concussion of the liquid molecules against the roughness of the sides, the other proportional to the velocity simply, and representing the effect of the cohesion overcome. M. de Prony, Eytelevein and others have adopted this view. The expression for the resistance should be increased by two terms proportional to the lateral wetted surface, which we indicate by S, and it is of the form W S $(a V + b V_2)$. By assigning to a and b the proper values the friction in front and behind may be taken into account. The total resistance is

$$R = k W A \frac{V^2}{2g} + W S (a V + b V^2) \qquad (B.)$$

III. A great number of writers have made experiments upon the resistance of fluids. Without speaking of Galileo, who was the first investigator, we may mention the experiments of Newton and Désaguliers, those of Borda, Hutton, Bossut, d'Alembert, Condorcet, Dubuat, Coulomb, Col. Beaufoy, Piobert, Morin, Didion, Col. Duchemin, and Thibault; and concerning the resistance of keels, Moll, Lebeulleur de Courlon, Bourgois, etc. Notwithstanding the multiplicity of these researches, and the care generally attending them, there is still great uncertainty with reference to the constants in the equation (B). This is due to several causes; first, to the inherent difficulty of the subject. It is difficult to produce a motion actually uniform; the measure of resistance is very delicate and is difficult to separate from the influence of the resistances of the apparatus employed. Again, the writers have almost all taken different points of observation, and this makes it difficult to compare their results. The majority have entirely neglected the lateral resistance; others who have taken it into account have represented it in formulas of interpolation of different forms distinct from formula (B). The coefficients of each experimenter correspond to the circumstances in which he is placed; and do not fit different conditions.

Still, to convey some idea of the value of the coefficients, we will give results selected from the best sources.

Dubuat caused 3 rectangular parallelopipedons with base a foot square, and having respectively altitudes of 4 lines, 1 ft. and 3 ft., to move in water. Neglecting lateral resistance, he obtained for k the values 1,43; 1,172; 1,102. But these coefficients seemed to him to vary with the velocity, a fact doubtless due to the neglected lateral resistance. In the experiments made by Borda upon thin plates moved in a circular direction, he obtained for k values varying according to the extent of surface, from 1,39 and 1,49 to 1,64. The radius of the mean circumference was 1,20 m. The variation of the coefficient was explained by the inequality of velocities at different distances from the axis of rotation. In similar experiments Hutton found $k = 1,24$ and 1,43; Thebault, 1,525 and 1,784; the latter with larger surfaces and higher velocities. For thin plates Col Beaufoy found $k = 1,13$; Col. Duchemin, 1,254. For prisms and cylinders moved in the direction of their axis, Beaufoy found values varying from

0,88 to 1,16. In all these experiments the coefficients diminished notably if the anterior ends had a rounded form. As to the lateral resistance, M. Bourgois, in a discussion of the experiments of Beaufoy, derived for a and b the following values :

In the first series of experiments,

$$a = 0{,}000125,\ b = 0{,}000102.$$

In the second series

$$a = 0{,}000100,\ b = 0{,}000125..$$

In the third series

$$a = 0{,}000024,\ b = 0{,}000156$$

In representing the friction of water in canals M. de Prony has used the values

$$a = 0{,}000044,\ b = 0{,}000309,$$

and Eytelwein, the values

$$a = 0{,}000024,\ b = 0{,}000366.$$

For conduits Prony gives

$$a = 0{,}000172,\ b = 0{,}000348.$$

Eytelwein

$$a = 0{,}000022,\ b = 0{,}000280.$$

These values refer to the mean velocity of the fluid, not to the velocity along the side.

The reader can consult "L' Introduction à la Mècanique Industrielle" of Poncelet, and M. Bourgois' "Memoire sur la Resistance de l'Eau," where the leading experiments are reported and discussed. The uncertainty affecting the constants shows that our knowledge in this matter is insufficient; and it explains why the theoretical researches of Daniel Bernouilli, Euler, Navier, Poisson, Caudey, and others, upon the important question of the resistance of fluids, have not yet led to any practical result. It is probable that the effects produced under the hypothesis that each element of the surface is subjected to the action of two forces, one normal, expressed by

$$k\,\mathrm{W}\,d\mathrm{S}\,.\,\frac{(\mathrm{V}\,\mathrm{Sin}\,i)^2}{2\,g};$$

denoting by i the inclination of the element considered with reference to the relative velocity; the other, tangential; expressed by

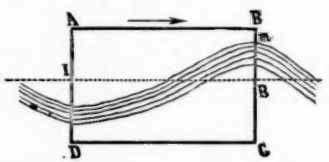
$$\mathrm{W}\,a\,\mathrm{S}\,(a\,\mathrm{V}\,\mathrm{Cos}.\,i + b\,\mathrm{V}^2\cos^2 i).$$

By projecting these forces in the direction of the motion, and integrating for the entire extent of the wetted surface, we should find the expression for the resistance for any assigned form; and a small number of well-conducted experiments, might possibly, with the aid of the method of least squares, determine the values of the coefficients a and b. But this work still remains to be done.

IV. According to Beaufoy's experiments, the resistance opposed to the motion of a body entirely submerged increases with the depth of immersion. Jorge Juan, a Spanish authority of good repute, in his "Examen Politico y Maritimo," says, that the resistance at an exterior point of a hollow vessel moving in water is proportional to the height due to the relative velocity with which the fluid would enter the vessel if the wall were pierced. The Marquis de Potesat in his "Theorie du Navire" has reproduced the ideas of Jorge Juan. This hypothesis makes the resistance depend on the depth of immersion; but ingenious as it is, it does not lead to results conformable to facts, and of course cannot be admitted. Still this point should be elucidated by special experiments, in view of the fact that the deviation of vessels driven by the screw propeller cannot be explained except upon the hypothesis of the increase of resistance with increase of depth.

V. In the case of floating bodies, the phenomena described at the commencement of this article, occur in the horizontal sections and the inferior portion of the body; but the free surface of the liquid presents new peculiarities. The molecules which meet the anterior face (B C, Fig. 3)

FIG. 3.



not being able to pass over this face, rise to a certain height proportional to the height due to the relative velocity; thus forming a kind of liquid cushion in front. But behind, there is a partial vacuum, into which the neighboring particles are precipitated, from which there results a lowering of the level at the posterior face A D. The difference of level at the points is called the *denivellation*. The molecules forming the cushion in front pass along

the sides in the curve represented in the figure. Let the dotted line represent the level of water before motion. If the anterior pressure is measured it is found greater than the static pressure P by a quantity proportional to $\frac{V^2}{2g}$, which may be represented by $m\,W\,A\frac{V^2}{2g}$; denoting by A the right section of the wetted portion and by n, a numerical coefficient. But if the pressure behind is measured it is found less than P by a quantity $n\,W\,A\frac{V^2}{2g}$. The difference of pressure may be denoted by $(m+n)\,W\,A\frac{V^2}{2g}$ or $k\,W\,A\frac{V^2}{2g}$; as in the case of a body entirely immersed. The lateral resistance can be expressed as in formula (B). But the denivellation produces another effect. It increases the surface in front by a quantity $m\,H$, proportional to $\frac{lV^2}{2g}$; l being the length of the prism. It diminishes the surface behind by a quantity proportional to the height due to the velocity of the molecules which descend from the level of the water to supply the vacuum; that is, it is proportional to $\frac{lV^2}{2g}$. Hence, the pressure in front is not $P+m\,W\,A\frac{V^2}{2g}$, but $P+m\,W\left(A+a\frac{lV^2}{2g}\right)\frac{V^2}{2g}$; a being a numerical coefficient. And for the posterior surface we have, not $P-n\,W\,A\frac{V^2}{2g}$, but $P-n\,W\left(A-\beta\frac{lV^2}{2g}\right)\frac{V^2}{2g}$, β being a new numerical coefficient. The difference of these pressures is

$$(m+n)\,W\,A\frac{V^2}{2g}+(m\,a-n\,\beta\,W\frac{lV^4}{4g^2}$$

or

$$k\,W\,A\frac{V^2}{2g}+k^1\,W\,A\frac{lV^4}{2g^2}.$$

The total resistance, therefore, is

$$R=k\,W\,A\frac{V^2}{2g}+WS\,(aV+bV^2)+k^1W\frac{lV^4}{4g^2}$$

The uncertainty affecting the coefficients of resistance in the case of bodies entirely submerged also occurs in the case of floating bodies. The majority of authorities have taken into account only the first term, neglecting lateral resistance and the effect of denivellation. Bossut, in experiments upon prisms with rounded fronts, found values of k less than unity. Dubuat obtained values varying from 1,11 to 1,14. The last value refers to a prism whose length was four times the height of a flotation, and for which the effect of denivellation, neglected by the author, must have been considerable. To the same cause are to be attributed the magnitude of the coefficients found by Col. Duchemin; these varied from 1,33 to 1,85. M. Poncelet thinks that the coefficient 1,1, is nearly correct in ordinary circumstances. According to Bossut, it should be less than unity when the prism has a rounded front.

As regards the keels of vessels, *though* the total number of experiments is small, the results are more precise and comparable. The application of screw propellers to navigation has furnished an exact and relatively easy way of obtaining an uniform motion and measuring the resistance. The best means seems to consist in causing the vessel to move uniformly by aid of a screw propeller tow-boat, and measuring the resistance by a dynamometer set in the tow-rope; taking into account the excess of tension due to the weight of the cable. M. Bourgois made several experiments, as well as M. Leboulleur de Corlon. Several scientific commissions have measured by this and other methods, the resistance of different vessels; among them Le Charlemagne, Le Napoleon, L'Audacieuse, and Le Primauget. Experiments have also been made in England. M. Bourgois, in his memoir already referred to, in his discussion of the several experiments has been led to the following conclusions. If, conforming to the usage adopted in the marine, we replace A by B^2 (B denoting the side of a square equivalent to the immersed surface midship) we can write

$$R=B^2V^2\left(\frac{k\,W}{2g}+\frac{W\,S\,a}{B^2V}+\frac{W\,S\,b}{B^2}+\frac{k^1\,W\,l\,V^2}{4\,B^2\,g}\right)$$

or, uniting the terms independent of the velocity,

$$R=B^2V^2\left(K_1+K_2\frac{lV^2}{B^2}+K_3\frac{S}{B^2V}\right)\quad(D.$$

putting

$$K^1=\frac{k\,W}{2g}+\frac{W\,S\,b}{B^2}\,K_2=\frac{k^1\,W}{4g^2},\;K^3=W\,a.$$

Mr. Bourgois has found that for sailing war-vessels, double-coppered and in good condition, the length being less than four times the breadth, we may write

$$R = B^2 V^2 \left(2^k,00 + 0^k,16 \frac{l V^2}{B^2} + 0^k,08 \frac{S}{B^2 V} \right) \quad (8.)$$

For men-of-war steamers, double-coppered, in good order, keel wooden and double-coppered, the length five or six times the breadth

$$R = B^2 V^2 \left(2^k,20 + 0^k,14 \frac{l V^2}{B^2} + 0^k,08 \frac{S}{B^2 V} \right) (9.)$$

For war-vessels, double-coppered, in good condition, of good model, the length not being more than four and a half times the breadth

$$R = B^2 V^2 \left(1^k,80 + 0^k,14 \frac{l V^2}{B^2} + 0^k,08 \frac{S}{B^2 V} \right) (10.)$$

For advice-boats of fine model, the efficient 0^k,14 should be replaced by 0^k,12.

These formulas give for R values whose mean is nearly 3^k, $3 B^2 V^2$, for velocities of 11 knots, or 5.65 metres per second, for ships, frigates, and even corvettes. But the resistance increases rapidly as the absolute dimensions decrease, a phenomenon due to the influence of denivellation. These facts accord with the old experiments of Bossut, which gave $k = 1,5$ for a prism with a base having the form of the vessel amidship.

To calculate the surface S, an empirical formula is used, by which we have

$$S = 0,6 \, L \, (l + t),$$

L being the length at water-line, l the breadth at beam, and t the draft; that is S is 0.6 of the lateral surface of the parallelopipedon circumscribed about the submerged portion of the hull.

VI. The experiments made in Scotland in 1833 upon rapid boats employed in navigation in canals, gave rise to the opinion that beyond a certain velocity the resistance experienced a considerable diminution. These experiments, which at that time made a great stir, gave rise to many industrial enterprises, which did not succeed; and many of these theoretical deductions have since been forgotten. The cause of the illusion was this: the liquid cushion which forms in front of a vessel moving in an indefinite fluid, forms a wave which is propagated like ordinary waves; but in a canal this wave, arrested by the sides, advances with difficulty, or not at all, in a narrow canal. This forms what Scott Russel calls the solitary wave. According to the experiments of McNeil on the Scotch canals, and of Morin on the St. Denis canal, the velocity of this wave is always that of the vessel, when its motion is uniform. If the boat receives a momentary acceleration, it may happen that it rises on the wave, the prow separating from the wave, as shown in Fig. 4;

Fig. 4.

and the resistance is for a moment diminished by a considerable quantity. But this is a kind of unstable equilibrium that will not last. If the boat slackens it resumes its place upon the crest of the wave, and the resistance resumes its first value; if the boat, on the contrary, receives a greater acceleration and rides the descending wave, then the solitary wave descends gradually, finally disappearing, and a new one forms in front. The diminution of resistance, therefore, follows some particular law, which cannot be considered as constant nor as a normal case. Separating the phenomena from the influence of the solitary wave, it is seen that the resistance increases with the velocity, not as its square, as Morin thought, but more rapidly, so that swift boats are governed by the general law expressed n formula (C). See the memoir of M. Bourgois already cited, and Poncelet's "Mecanique Industrielle."

VII. We have said that the laws of resi tance should depend solely upon the relative velocity. But the accurate experiments of Dubuat and other authorities have led to a greater value for resistance in the case of a solid body at rest in a moving fluid than in the case of a solid body moving in a fluid at rest. Two considerations explain this apparent paradox. In experiments made upon rivers or artificial canals the *mean* velocity has generally been taken as the velocity; this is less than the velocity at the middle of the stream, where the body experimented upon is generally placed. If R is the observed resistance and U the mean velocity, we determine the coefficient k by the relation

$$R = k.W.\frac{U^2}{2g}$$

$$\therefore k = \frac{R \cdot 2g}{W U^2}$$

Using the velocity at the middle, V, for the same resistance,

$$R = k'.W.\frac{V^2}{2g}$$

$$\therefore k' = \frac{R \cdot 2g}{W v^2}$$

and

$$k = k'\frac{V^2}{U^2}$$

Hence one generally obtains a coefficient k greater than the actual coefficient k'. Again, in order that a fluid move uniformly, it is necessary that its surface should be inclined; the body and the fluid are therefore in the same relative situation as if the body were moving up an inclined plane formed by free surface of the fluid; consequently the resistance should be increased by the circumstance.

IRON AND STEEL NOTES.

Bessemer and Crucible Steel Castings for Gun Barrels, etc.—The great demand since the commencement of the war on the Continent for rifles has led to the adaptation by Mr. Foster, of Sheffield, of a patent by means of which barrels can be cast from a hollow bloom. They are cast with a chill centre, and then rolled into the centre instead of being drilled, and so preserving the original skin of the metal, and maintaining its strength of a uniform character. By being case-hardened they wear longer without fouling, are not liable to corrosion, whilst the cost is scarcely so much as the ordinary barrel. Mr. Foster has just had a Chassepot barrel cast, and it appeared to be all that could be desired. The invention is applicable to steel hoops for railway wheels, gun barrels, and the casting of cylindrical forms in Bessemer or crucible steel. The object of the improvement is to save the preliminary processes in the production of a "bloom" by casting it in a metal mould, with a movable metal pin centre, or core and cover, by which means a bloom is produced, and when re-heated is ready to be rolled and finished without requiring to be cut, hammered, or shaped, and so preserving the original skin of the metal without injury, giving increased strength to the article so produced. In carrying the improvement into practice a metal mould (by preference of cast-iron) is arranged in combination with a movable centre pin or core, and a cover or lid, which is also movable. The centre or core, with the lid or cover, are held in position by a colter, or otherwise, in such a manner that the cover can be caused to make a partial revolution to break off or remove the "get" or runner of the casting directly after the melted steel is run into the mould, the centre pin or core being then forced out, either upwards or downwards, as may be found most convenient, thus leaving the steel to contract uniformly throughout. The interior capacity of the mould is suited to receive the exact quantity of steel required for the production of a "bloom" for a hoop, tyre, or other article of given weight and dimensions. The metal centre or core may be made either solid or hollow. In like manner cylindrical forms may be made of cast-steel suitable for other purposes. Mr. Foster is at present in treaty for the production of a large number weekly of gun-barrels, and the invention is likely to turn out a very valuable one, and also effect a great improvement in the production of barrels of every description.—*Mining Journal.*

Interesting Experiments in Steel Manufacture.—We learn from the Troy "Press" that Mr. G. W. Ballou, President of the Knickerbocker Manufacturing Company, of Vermont, assisted by Dr. C. M. Neo, has lately been conducting in that city some interesting experiments in the manufacture of steel, which have attracted much attention among the iron and steel men of that locality. The object of these experiments was to test the qualities of the Codorus ore, and they are said to have been completely successful. One ton of Codorus ore was melted in a puddling furnace with five tons of common domestic pig, and the product was found to be five tons of steel of a good quality and capable of taking a high temper. The ore acts as a purifier, or vehicle for carrying the phosphorus, sulphur, and from the molten mass; and although a chemical analysis of this ore reveals the presence of no component element not belonging to iron ores in general, there is some allotropic condition or combination which gives it the peculiar qualities which render it so peculiarly useful for the conversion of pig-iron into steel. Subsequent to Mr. Ballou's experiments at Troy, a few heats were made at the Albany Iron Works. The ore and iron, thrown together into the puddling furnaces, were melted and balled up in an hour, resulting in steel which, when made up into cold chisels and tested, was found to cut English cast-steel. Another experiment, made about the same time at the Empire Foundry, which consisted in melting Codorus ore with Hudson River No. 2 iron in a cupola, was also found to be completely successful, and a trial of its properties in connection with fragments of burnt out iron, consisting of an old gas retort, grate bars, etc., showed that it imparted to such metal in the furnace the qualities in which it was most deficient. Experiments are shortly to be made with rolled rails of Codorus steel, with a view to testing their strength as compared with other all-steel rails of good quality, and much interest is manifested in the result.—*Iron Age.*

Improved Manufacture of Steel.—Mr. C. L. Franke, of Finsbury, has just patented the following chemical mixture for making steel of high quality:—26.9 parts of boracic acid, 21.5 parts of spathose iron ore, 13.4 parts of hydrochlorate of soda, 10.3 parts of prussiate of potash, 8.6 parts peroxide of manganese, 6.1 parts of dry carbonate of soda, 3.9 parts of magnetic iron ore, 3.7 parts of graphite, 2.8 parts of cyanide of potassium, 2.8 parts of red iron ore. Total parts, 100.

Cast-iron is melted in a puddling or similar furnace, together with 7 or 8 per cent. of hammer slag, and 1 or 2 per cent. of the chemical mixture. The metal is well rabbled so as to thoroughly mix

it with the chemicals. When it boils, as it will do under this treatment, a further quantity of the chemical mixture is added, say about 1 per cent. Afterwards the metal is balled up, and it may then be hammered or squeezed and rolled into bars in the usual way. This steel may in the form of puddled ball or otherwise be melted in crucibles for the manufacture of cast-steel; sometimes the puddled balls or other blocks or pieces of steel are heated and sprinkled with about 1 per cent. of the chemical mixture. A number of puddled balls are then welded together, and drawn down so as to obtain a forging of any required shape.

RAILWAY NOTES.

NARROW GAUGE RAILWAYS IN THE UNITED STATES.—There are few questions of more practical and pressing importance in the present day than the best means to be adopted for extending our railroad system (carrying with it as it does fresh life and energy into all the districts which it penetrates) into the territories and other parts of this vast Union, where the traffic to be expected, at any rate for years to come, cannot be such as to warrant a large capital expenditure.

It is therefore with much satisfaction that we place before our readers the following information kindly given to us by Sir Charles Fox & Sons, the well known civil engineers of London, who have for many years been actively engaged in practically working out a similar problem in Australia, India, and Canada.

Their object has been to construct railroads, which, whilst very economical in first cost, should be substantially built and equipped, and therefore operated and maintained at a moderate percentage of the gross income.

Mr. Carl Pihl, the engineer of the Government railway of Norway, has also for some years been carrying out very successfully a system almost identical with that under review.

The question of gauge is one which requires to be determined after careful investigation of the circumstances in each case. Where a standard national gauge exists, caution must of course be exercised in introducing any diversity; and yet it may, upon examination, be found that to adhere in all cases to the gauge suitable for trunk roads would be to check, nay, even to prevent, the constructing of many tributary or branch roads, in themselves most necessary for the development of the country. Thus, in the vast empire of India, where the trunk roads have the 5 ft. 6 in. gauge, the Government is seriously and favorably entertaining the question of adopting a much narrower gauge for the tributary roads, to open up the country.

With the above reservation, Sir Charles Fox & SONS, and others interested in this question, have found, after an experience spread over many years, that the most economical gauge for such tributary roads which can be used with advantage is that of 3 ft. 6 in. A broader gauge than this is, in their opinion, for speeds of 25 miles an hour and moderate traffic, quite unnecessary, and of course involves additional outlay, especially if the country is of a h lly nature. To use, on the other hand, a narrower gauge than 3 ft. 6 in. is likewise very objectionable, and especially so where wood is the fuel chiefly employed, as on very narrow gauges it becomes impossible to use either boilers or fireboxes of such dimensions as to give satisfactory results.

The following are given as examples of railroads which have been built, or are now in progress of construction upon this gauge:

EXAMPLES AND COST IN GOLD, INCLUDING IN EACH CASE STATIONS, ROLLING STOCK, ENGINEERING AND ALL MANAGEMENT EXPENSES.—1st. The Queensland Railways, Australia. Length, 222 miles; gauge, 3 ft. 6 in. Wages: skilled laborer, $2.50 to $3.10; ordinary do., $1.50 to $1.75. Average cost per mile, $32,000.

2d. The railway from Conyeveram to Arconnur, India. Length, 19 miles; gauge, 3 ft. 6 in. (Land and portion of road-bed given by Government.) Materials chiefly sent out from England. Rails 35½ lbs., iron. Average cost per mile, $19,000.

3d. The Toronto, Grey and Bruce, and the Toronto and Nipissing Railways, Canada. Length of first section, 193 miles; gauge, 3 ft. 6 in. Wages: ordinary laborer, $1 to $1.50. Average cost per mile, $14,150.

4th. The Government railways, Norway (constructed by Carl Pihl, C. E.). Length, 106 miles; gauge, 3 ft. 6 in. (Rails and many other materials sent out from England.) First, through easy country, $15,900 per mile; second, through heavy country, $23,700 to $26,150 per mile.

It will be seen that, the two first of these principles being conceded, it at once becomes possible to construct a thoroughly substantial track with rails not weighing more than from 30 to 40 lbs. per linear yard, provided that the ties are laid sufficiently close, the rails well fished at the joints, and an ample supply of ballast provided.

The speed of 25 miles an hour is found in practice to be more than sufficient for tributary roads. A load of 4 tons per wheel is sufficient to enable the passenger and freight cars to be of ample dimensions for convenience of traffic.

The passenger cars of latest design are of the usual American type, 32 ft. long, exclusive of platforms, and 8 ft. 6 in. wide, carrying very comfortably 32 passengers. Their centre of gravity being very low, they run with great steadiness. The box cars are 15 ft. long and 8 ft. 6 in. wide. The platform cars are 24 ft. long and 8 ft. 6 in. wide, and carry 10 tons, their own weight being only 5 tons.

It will thus be seen that the non-paying load, or dead weight, is reduced from the usual proportion of one-half to one-third of the gross weight; and from this results an important saving in operating expenses.

The locomotives are generally of 2 types.

Type 1, or freight engine, has 11-in. to 12-in. cylinders; 6 coupled wheels, 3 ft. 3 in. in diameter, and a 4 wheeled bogie, and weighs about 20 tons, exclusive of tender.

Type 2, or passenger engine, has 10-in. to 11-in. cylinders, 4 coupled wheels, 3 ft. 3 in. in diameter, and a 4-wheeled bogie, and weighs about 16 tones, exclusive of tender.

The maximum grades vary from 100 to 132 ft. to the mile. The sharpest curves are of from 500 to 330 ft. radius. The grading has generally a width in cuts of 15 ft., and on banks of 12 ft. The bridges are sometimes of iron, with masonry substructure, sometimes altogether of timber. The depots are of neat but economical design. The railroads are generally fenced throughout.

On the Canadian roads careful arrangements are

made to protect the track from snow and to provide in every detail against the effects of frost.

The cost of the Canadian roads, viz., about $14,000 per mile, may be taken to fairly represent the probable outlay (including evrey expense of right of way, management, etc.) for the building and equipping of a road of this gauge through an undulating and well-settled country, involving considerable expenses for right of way, say, 15,000 cubic yds. of grading per mile; frequent road-crossings, fencing throughout, and a fair proportion of bridges, depots, side-tracks, and an ample equipment for a considerable traffic.

On the other hand, in the great prairie country of the West, where right of way, grading, and bridging are at the minimum, where 36 lbs. rails would be ample, where fencing is not necessary, and where the provision for depots, side-tracks, and equipments, could be materially reduced, a well constructed and substantial railroad of the 3 ft. 6 in. gauge may be completed *and equipped* ready for operating, with an expenditure not exceeding from $8,000 to $10,000 *per mile*, and on such a road, as both grades and curves would be easy, trains carrying a net load of 100 tons of freight could be operated with facility, at a speed of from 20 to 25 miles per hour.

Operating.—So far as the gauge is concerned, the cost of traction would be very much the same per train mile, and per ton, as on railroads of the ordinary 4 ft. 8½ in. gauge, were it not reduced by the much more favorable proportion which the net or paying load bears to the gross weight of the train. Moreover, in consequence of the lower speeds and the light-rolling loads, there is on these light railways a most important saving in wear and tear, both of tracks and equipment, and the total cost of operating is therefore considerably reduced.

Peru is constructing 3 great railroads to connect her coast with the countries east of the Andes. The one from the coast to Arequipa, and across the Andes to Puno, and thence to Lake Titicaca, on the dividing line between Peru and Bolivia, is progressing favorably. Forty miles have been finished between Arequipa and the coast, and traversed by powerful engines with construction trains. There are 6,000 laborers at work on the road. The difficulties of the mountainous ground are tremendous, bu t have been triumphantly overcome. Many o :the huge cuttings and embankments have called out the highest kind of engineering skill. Within 6 months the ancient city of Arequipa, founded by Pizarro, away up in the vale of the Andes, will be in close communication with the coast. The region around Arequipa is rich in silver and copper mines, and produces cotton, wool, sugar, and nitre, the exports of which have been comparatively inconsiderable for want of cheap transport. This the railroad will give, and will inspire new life into the commercial and social relations of those productive but hitherto little known elevated valleys of the Andes.

By the census of 1870, the population of Minnesota, is given at 435,511; of Washington Territory, 23,901; of Oregon, 90,922. The population of the intermediate territories, are Dakotah, 14,-181; Montana, 20,594; Idaho, 14,998. We are not in possession of any returns of population of the British possessions, but there are many important settlements which will be tributary to the Northern Pacific road. With regard to Minnesota, the division extending from Lake Superior to the Red River of the North, 250 miles, is now well advanced, and it is expected that by mid-summer this section will be in full operation. This division includes a branch to Pembina, on the British border; besides which, the finished line of the St. Paul and Pacific road, recently purchased and consolidated with the Northern Pacific, will give to the Company 600 miles of road in Minnesota, completed or under construction. Meanwhile, orders have been sent to the Pacific for the commencement of work on the western section early in the spring, when the work will be pushed forward in both sections as speedily as is consistent with solidity and economy.

As an important adjunct to the road, the company is now organizing a department of Emigration and Colonization, claimed to be comprehensive, practical, and on a scale hitherto unattempted by any corporation or government.

The extensively ramified connections of the house of Jay Cooke & Co., in Europe and America, no doubt, afford important facilities in aid of this scheme.

We have already pointed out, in a general way, the principles which must insure the prosperity of the road and country through which it passes. The following points, as set forth in the prospectus of the Company, present a more particular view of its commercial advantages:

The business of the road, immediately on its completion, and even during construction, will be very large, and will consist mainly of: 1. The transportation of Government mails, troops and military supplies. 2. The large local carrying trade of the present population of the States and Territories traversed. 3. The entire trade of the important British settlements occupying the rich valleys of the Red and Saskatchewan rivers, the Winnipeg basin, and the fertile plains of British Columbia, on the Pacific slope. 4. That portion of the large through business between the Atlantic and Pacific oceans, which will certainly pass over this line, owing to its great superiority in directness, shortness, and ease of grades. 5. The constantly increasing carrying trade of the millions of people who will soon occupy the magnificent country through which the road passes, and the transportation of whose supplies and products alone, will speedily constitute a paying business for one line of road.

This road will unite Lake Superior and St. Paul with Puget sound—and hence the commerce of the lakes and of the Mississippi river with that of the Pacific Ocean—by a line, counting actual distance and difference in grades, at least 500 miles shorter than the present one connecting Lake Michigan and San Francisco. By it, Liverpool and New York will be brought 1,400 miles nearer than now to the ports of China and Japan. It will be the only-trans-continental line under one control.

Branch lines or feeders will be built from the Trunk road, northward and southward, so as to drain the entire region north of latitude 42 deg., and render the future construction of additional east and west lines within that belt unnecessary.

In consequence of this difference of elevation, the road will in ordinary winters, be less encumbered by snow where it crosses the mountains, than are the passes at the elevated more southerly points. The difference of 5 to 6 deg. of latitude is more than compensated by the reduced eleva-

tion, and the climatic effect of the warm ocean-currents from the equator, which strike the Pacific coast and extend their tempering influence far east of the Rocky mountains.

In conclusion, we give the following approximate estimate of the cost of construction, made by the chief engineer of the Company, W. Milnor Roberts, Esq., who with others, in 1869, made a preliminary survey of the line of road:

Grading, masonry, bridging, track and ballast	*$60,320,000
Sidings, etc	4,200,000
Contingencies, including superintendence and engineering	5,000,000
Telegraph line	600,000
Buildings	2,312,000
Rolling stock	3,615,000
Branch road	1,200,000
Extra works, etc	800,000
	$78,047,000
Interest on bonds over receipts during construction	7,230,000
Total	$85,277,000

This gives an average of $42,638 per mile.

As the line of country over which the Northern Pacific railway is building, presents the compensation of lower altitude for higher latitude, in contrast with other routes, we present a comparison of grades:

Northern Pacific to	Miles.	Average height above the sea.
Dakota valley	300	1,200 feet.
Yellowstone river	300	2,200 "
Along Yellowstone	400	2,500 "
Flathead valley	300	3,500 "
Lewis or Snake river	200	3,000 "
Puget sound	500	400 "
	2,000	
Lake Superior to Puget sound via Portland	2,000	
Direct line	1,775	

Central Pacific—from Chicago to	Miles.	Average height above the sea.
Omaha	491	1,000 feet.
Cheyenne	516	3,300 "
Cooper's	86	7,300 "
Promontory point	482	6,200 "
Humboldt	408	4,750 "
Reno	130	4,000 "
Auburn	118	4,400 "
Sacramento	36	300 "
San Francisco	138	50 "
	2,405	

The future which this movement unfolds, belongs to that domain in which facts make up a grandeur glorious as the imagination loves to draw. It makes new States for the American Union. It will bring about the greatest alliance yet of American and European capital. It will give ready connections with the fisheries of the North Pacific. On the direct line to the East, Shanghai comes more than 1,500 miles nearer to our Atlantic coast. From the wharves on Lake Superior, vessels can pass with unbroken cargoes to the great ports of Europe. But to describe all the ends it will serve, transcends our ability. To us it is, as it will be found by others, a study which gives a larger understanding of the probabilities of the age in which we live.—*From the American Exchange and Review.*

* Being the estimated cost apart from siding, etc., of the six divisions, viz.:

No. of Div.	Description of Divisions.	Miles.	Estimated Cost.
1.	Lake Superior to Yellowstone river	550	$13,750,000
2.	Along the Yellowstone to Bozeman's pass	420	11,760,000
3.	Bozeman's pass to Heligate river, Mountain division	225	9,000,000
4.	Heligate river to Pend d'Oreille lake,	205	7,000,000
5.	Pend d'Oreille lake to the mouth of Lewis river	223	7,500,000
6.	Mouth of Lewis river to Puget sound, Columbia Valley division	377	11,310,000
			$60,320,000

ORDNANCE AND NAVAL NOTES

THE PRUSSIAN NEEDLE-GUN.—The superiority of the present method of loading fire-arms at the breech over the old-fashioned manner of loading at the muzzle, is now universally conceded. Arms constructed on this principle are peculiarly adapted for the military service, on account of the confidence which they inspire in the troops so armed. As complete a revolution in the science of warfare has been effected by the introduction of the breech-loading system, as was formerly produced by the substitution of rifles for smooth-bores, or the percussion-cap for the flint lock. This innovation has been gradual, for the principle itself is by no means novel.

Henry II. of France is supposed to have invented breech-loaders as early as 1540; but in China and some parts of the East this principle had been applied to large guns many years before. The wall pieces of the French were so constructed at a later period, and still later a chamber-loading musket was used by some of the Norwegian infantry. But the Germans are entitled to the credit of having early recognized the great importance of inserting the charge in the breech for the purpose of facilitating the loading and thereby increasing the rapidity of fire. In advance of all other nations they extensively adopted in their army a gun so arranged, known as the needle-gun.

It has been erroneously asserted that this gun was invented by an Englishman named Sears, and exhibited in England prior to its adoption by the Prussians. This misapprehension has arisen from the fact of a gun having been invented by M. A. Sears, of London, after the Prussians had adopted theirs. The real inventor was a manufacturer of guns at Sommerda named Dreyse. His first model was made in 1835, and was a muzzle-loader. In this early model the rear end of the barrel, or breech, was securely closed by two screws, one in front of the other, with an intervening space containing a sliding needle operated by a spiral spring. At the bottom of the cartridge there was a priming of a very explosive composition, which ignited the charge of powder by the friction of the needle penetrating it. On account of the highly explosive character of the cartridges, premature explosions frequently occurred while they were being rammed from the muzzle. The balls did not always expand into the grooves and take the rifling of the barrel, on account of too great windage. These serious defects, which impaired the efficiency of the gun, caused the inventor to change the method of loading from the muzzle to the

breech, and originated the present form of the needle-gun (zundnædel gewehr).

It was first distributed to the Guards of the Prussian army as a rifle in 1848, and gave great satisfaction. During the Schleswig-Holstein war the needle-rifle was tested in service a little, and the trials resulted favorably. In 1855 a rifle-musket (needle) was issued to those regiments of infantry that were without the rifle. Subsequently some of the chasseurs and riflemen of the Guards were armed with the rifle, it having an improved sight and a different form of ball.

The needle-gun is so called from the thin wire or needle which discharges the piece. The weight of the rifle is 11 lbs. 4 oz., and it is capable of being fired about seven times per minute. It is composed of three principal parts—the barrel, the stock, and the breech-loading mechanism, including the needle, etc. As the stock does not differ materially from those of other arms, no description is necessary. It is somewhat straighter than those of this country, and made from lighter wood.

The barrel is rifled for three feet of its length, and has a bore about six-tenths of an inch in diameter, with a chamber for the cartridge in the rear end, which is slightly larger than the bore. The rifling consists of four grooves of uniform depth and width; each .24 in. wide, and .03 in. deep, with a uniform twist of five-elevenths in the length.

The mechanism for loading at the breech is a slide or plunger that opens or closes the rear end of the barrel by sliding in a cylindrical socket fastened to the barrel by a screw thread. This socket or cylinder incloses all the mechanism for loading, and is attached to the stock by a tang and screw, which also passes through the trigger-plates. The cartridge is inserted into an opening on the right side of the socket, and forced into the chamber by the plunger, operated by a knob handle. This plunger is a cylinder having its front end reamed out to fit the end of the barrel, which is cone-shaped externally. An air-chamber is formed in the plunger by a space between its front end and the chamber of the barrel, that contains a tube called a needle conductor through which the needle slides. The needle conductor is screwed into an iron plate in rear, that receives all the force arising from the reaction of the gas at the instant of discharge. Behind this, another tube is situated (called the locket) which contains within it a small tube with projecting rings and a spiral spring inclosing the needle. The locket has a slot and recess for its spring.

The needle is a very thin steel wire, sharpened at the front point, and soldered at the other end to a brass stem, which is screwed into the tube with the spiral spring,

Although the spiral spring is quite light, it will support a weight of eleven pounds. On the under side of the cylinder is the trigger, trigger-spring, and stop. The trigger is an irregular-shaped bent lever, which accomplishes the discharge of the rifle when pressed, by releasing the lock of the needle.

For the rifle the cartridge is composed of a sphero-conical leaden ball of 450 grains weight, a paper sabot with a priming of fulminate, and a charge of 56 grains of powder enveloped by paper. The sabot is a paper wad, shaped in dies by machinery to fit the spherical base of the ball, with a recess in its bottom for the priming. In the manufacture and preparation of the explosive composition, the greatest secrecy has been observed by the Prussian authorities—an unnecessary precaution, as either of the fulminates of mercury or silver are as good, if not a superior agent. Behind this wad is the charge of powder, so that the needle, to reach the priming, penetrates the charge, and the grains of powder nearest the ball are first ignited. By this method of ignition the ball is started before it is acted upon by the explosive force of all the charge, and increased range and diminished recoil are claimed.

The rifle-musket, before alluded to, is lighter than the rifle, weighing only 10 lbs. It has five grooves of uniform depth and twist, of one turn in 64 in. The ball is a cylinder with a conical front, and weighs 705 grains; 79 grains of powder is the charge. The sight for the rifle is only graduated to 490 yds.; for the musket, it extends to 1,000 yds.

Such is a brief description of the famous gun with which the Germans waged their successful war against Austria, and demonstrated to the world the advantages of the breech-loading system. But notwithstanding some merit which their boasted gun certainly possesses, there have been so many important improvements made since the invention of the needle-gun that it has ceased to be even an efficient weapon in comparison to those of later date. It owes its celebrity only to the fact of its being the first breech-loader used extensively for military purposes, and as a type of the new system. Even to this day, on the plains of the West, its name is synonymous with that of its method of loading, and all such class arms are called needle-guns.

An enumeration of the many systems of loading at the breech would fill a volume. They have been classified into two divisions—the old and new. The latter include all those that are arranged for a metallic cartridge, while the old class use paper ones.

One of the great objections which has been urged against loading at the breech, is the difficulty of forming such a tight joint at the point of explosion, as to prevent the escape of considerable gas. This is remedied by the use of the metallic case cartridge, which acts as a gas check. Such a cartridge is in use in our service, and is vastly superior to the paper cartridge of the Prussians. In fact, the needle-gun, for rapidity of fire, accuracy, range, penetration and endurance, is far below the standard of the U. S. Springfield breech-loader.

In March last a board of officers convened in St. Louis for the trial of small arms, and subjected the Springfield musket to the following severe tests:

For exposure to the weather—five hundred rounds to be fired without cleaning, and exposed to the sun and rain.

For effects of sand and dust on the breech mechanism—eight shots to be fired, then fine sand to be sifted over the breech mechanism, closed; eight shots, and fine sand sifted over the same parts open, and nine shots fired.

For effects of salt water—the arm to be placed three hours in brine, then exposed in open air until next day, and fifty shots to be fired.

For strength of breech mechanism—to be fired once with double and once with triple charge of lead and powder.

The musket stood the above trial, and worked well when quite rusty.

The complicated and delicate mechanism of the

needle-gun is ill adapted for such experiments. It would be absurd to institute a comparison between the two arms. An invention of nearly thirty years ago in this progressive age of advancement in all mechanical contrivances, cannot compete with anything modern, and the needle-gun would prove a clumsy weapon if it were matched against an English or American rifle of late pattern.

ENGINEERING STRUCTURES.

Wire Tramway in Colorado.—We make the following extract from a letter from Mr. Geo. W. Cypher, of Lambertsville, N. J. It describes a wire-rope tramway, constructed by Mr. Cypher for the Brown Silver Mining Co., of Clear Creek Co., Colorado, in 1868:

It consists of two main cables, 1½ in. in diameter, securely anchored in the rock at the head of the plane 7 ft. apart, then passed over a tower 15 ft. high, and at points down the mountain where, comparatively secure from avalanches, are supports at intervals of from 250 ft. to 370 ft., capped with cast-iron saddles, in which the cables rest in such manner as will permit a pulley running on the cable to pass freely over them.

At the foot of the plane the cables are each attached to an eye-bolt 3 ft. long, with thread cut for 2 ft. of its length, and pass through a brass beam at the top of a tower 30 ft. high. The long eye-bolt is intended to take up any undue slack that may take place from the striking of the cable.

The tower is prevented from overturning by two short cables attached to its top and pass back and down to a timber crib filled with stone.

This completes the track ready for the cars.

The cars are made of stout sheet iron, the bodies kept about level by the upper suspender being the longer. The suspenders stand "fore" and "aft," so that the pulleys are 9 ft. apart, with gas pipe strut to keep them in position. So each car is suspended on two pulleys, 9 ft apart, and 13 in. in diameter. One car being on one main cable at the head of the plane, the other on the other cable at the foot of the plane, a wire rope, ⅝ in. in diameter, is passed round a grooved wheel of diameter equal to the distance between the cables (7 ft.); placed horizontally in the tower at the head of the plane, and crossed in front; it is attached to the upper end of each car. This grooved wheel has a hand-brake on it, to regulate the speed of the cars when descending.

From 1,500 to 2,000 lbs. of ore is taken at one load.

On reaching the foot of the plane, the car is dumped by dropping the bottom, the ore descending by a shoot into a bin near the crusher.

To keep the cars steady in position, and to prevent them running up the plane back and fore when the load is discharged, a counter or tail-rope, of ⅜ in. in diameter, is attached to the lower end of each car, and passes round a grooved wheel, suspended in a sliding frame in the tower at the foot of the plane. The running-rope and tail-rope are carried over rollers at each support along the line.

This arrangement has been in constant operation since September 1st, 1868, and was divulged by me the forepart of June, 1868.

There are now quite a number of planes on the same plan in operation among the mountains of Colorado.

During July, 1868, and while putting up the plane on Brown Mountain, I proposed to erect a line 4 miles or even 8 miles up Clear Creek, to transport freight and passengers, and use the water-power of Clear Creek to propel the cars.

I have no patent, for the reason that at that time I did not deem the invention of sufficient importance. But, as the system has since attracted considerable attention among scientific men, I feel that I am entitled to a share of the credit of originating it, and, at all events, to prevent any one else claiming the invention and patenting it in this country.

Postal Pneumatic Tube.—A large party of visitors were invited, on Saturday, to the General Post-office, to see the working of a new line of pneumatic tubes for the telegraph service, between Telegraph street, in the City, and Temple bar, upon the Siemens principle, originally brought out in Berlin some five or more years ago, but now for the first time adopted in this country. Pneumatic carrier-pipes, upon Mr. Latimer Clarke's system, have long been in use at the Telegraph street station for short distances eastward, but the present line is the first coming thence westward. In the Clarke system, the two sets of pipes are open at their terminal ends, and are both worked by a steam-engine at the head station, which forces air into one stationary cylinder or receptacle there, and exhausts a vacuum in another. The carrier-box, in which the messages are placed, is thus blown through the "down" tube and sucked back through the "up" tube. The service is admirably conducted in this way from one place to another, but no intermediate station is practicable. In the Siemens system, the "up" and "down" tubes are continuous, the engine pumping air into the one end and exhausting the other, so that a continuous circulation is maintained, and which can be cut by any number of intermediate stations. These "stations" are formed by short lengths (about 2 ft.) of double tubing, placed parallel side by side, inserted in the main pipes, and working backwards and forwards on a rod or hinge. One of these, the "siding," is covered with a glass top, and has a perforated stop at one end, against which the carrier-box is "trapped" or stopped, the perforations in the "stop" allowing some of the current of air to pass through, so as not to arrest the circulation of the air-current, which is further completed by a bent tube passing over from one end of the main tube to the other across "the station," and actuated by a throttle-valve. The "main line junction-pipe" and its companion "siding" are worked on the same "block" system as the metropolitan lines of railway. A signal-bell or gong denotes that a "carrier" has been dispatched by the "up" or "down" tube respectively, and the number of the sounds struck indicate the station it is intended for. That station immediately puts on its "siding," and as soon as the carrier arrives it is duly "trapped." The "siding" is then brought over, and a straight rod inserted forces the carrier-box out, and the messages are duly received. In passing intermediate stations, the carriers strike the stud of a bell inserted in the main tube junction-pipe, and notifies its transit; the object of the "block" system being that two "carriers" shall not be in the same length of tube at the same time, for fear of stoppages at any sharp turns or bends; for, although, if any such accident occurred, it could be readily

relieved by reversing the air-current, it is desirable in a public service to have no chance of any, even temporary, interruption. The length of the new pneumatic line is about a mile and a quarter. From Telegraph street to the General Post-office, 880 yds.; thence to Temple bar, 1,330 yds. The system was explained by Mr. R. S. Curley, C.E., the engineer-in-chief of the telegraph lines. Working with pressure and vacuum, or by the proper circulation, the time taken by the "carrier" from Telegraph street to the General Post-office was 1¼ minutes; thence to Temple bar, 2½ minutes; or right through the whole distance in 4 minutes. Worked by vacuum only, the "carrier" took 8½ minutes for the same total distance.

CENTRIFUGAL PUMPS.—At a meeting of the Institution of Civil Engineers held on the 14th inst., the second paper was on Centrifugal Pumps, by Mr. D. Thomson, Assoc. Inst. C. E. In this communication a short sketch was given of the early history of centrifugal pumps, and it was stated that their practical introduction as useful machines dated from the Exhibition of 1851. The author attributed to the late Mr. J. G. Appold, Assoc. Inst. C. E., the principal merit of bringing them to such a stage of perfection as to make them generally available. Mr. Appold made numerous and careful experiments, and the results thus arrived at had been confirmed by the author's experience.

The practical rules of construction were thus stated:

1. The arms of the fan were curved backwards, according to principles of construction which were explained by diagrams. The depth of the fan was one-fourth of the diameter, and the central opening for the admission of the water was about nine-sixteenths of the diameter. The space allowed in the case round the fan should be of ample dimensions.

2. The best duty was given when the speed of the periphery of the fan exceeded the velocity of a falling body due to the height of the lift, by from 6 ft. to 8 ft. per second.

3. A fan 12 in. in diameter, and proportioned as described, would discharge 1,200 gallons of water per minute.

4. If the diameter of the fan was varied (the speed of the periphery and the lift remaining the same) the delivery of water was increased or diminished directly as the square of the diameter.

5. When a centrifugal pump, properly proportioned, was worked by a steam engine, the duty that might be realized ranged from 55 per cent. in the smaller-sized pumps to 70 per cent. in the larger machines, of the power shown by the indicator diagrams.

The theoretical principles on which the curves of the arms should be formed were explained and illustrated by diagrams, and easy methods were described of arriving at close approximations to these curves by arcs of circles. The conditions under which centrifugal pumps could be most advantageously used were stated to be when the lifts were low, not exceeding 30 ft., and especially when the lift was also variable, as the centrifugal pump had a self-adjusting property, by means of which as the lift diminished the quantity of water discharged increased. The tabulated results of experiments made with centrifugal pumps for emptying graving docks at West Hartlepool and at Leith, showed this self-adjusting quality of the pump, and generally illustrated the principles explained in the paper.

Drawings were given of three different kinds of centrifugal pumps that the author had made, adapted for different circumstances, and the special advantages of each were explained.

A note was appended to the paper, embodying a theoretical investigation as to the statical height of the column of water that a centrifugal pump should sustain by a given speed of the fan, and this was shown to be expressed by the formula

$$S = 9.82\sqrt{h}$$

where S = the speed of the periphery of the fan in feet per second, and h = the head of water supported by the pump in feet, no water being discharged.

It was shown that owing to the water exterior to the fan being carried round by fluid friction, the speed of the periphery must always be less than this, and in the smaller pumps it was found experimentally to be more nearly expressed by the formula

$$S = 8\sqrt{h}$$

—*Engineering.*

NEW BOOKS.

DESILVERIZATION OF LEAD BY ZINC. Translated by FREDERICK PRIME, Jr. New York, 1870. For sale by Van Nostrand.

This valuable memoir appeared sometime since in the columns of the "Technologist." It now appears as a neat little pamphlet of 20 pages, with folding plate and tables. The process, as described, consists of three stages. 1. Desilverization of the lead. 2. Refining the desilverized lead. 3. Treatment of the zinc scum. Compared with the Pattinson process, it is believed to possess great advantages.

THE QUARTZ OPERATOR'S HAND-BOOK. By P. M. RANDALL. Revised and enlarged edition. New York: D. Van Nostrand.

The object of the author in the preparation of this work has been to present a clear and comprehensive exposition of mineral veins and the means and modes chiefly employed for the mining and working of their ores, more especially those containing silver and gold.

The writer has had a large experience from which to draw material for the present book, but he has also availed himself of the skill and experience of other practical miners and millwrights, and duly acknowledges the same in the preface.

As is usual with works of such a technical character, an outline of the theoretical principles involved is added for the benefit of such readers as find the more complete treatises inaccessible. This applies in both Mechanics and Chemistry.

A collection of tables to aid in the calculations, is placed at the end of the book.

THE SUN RULER, FIRE, LIGHT, AND LIFE OF THE PLANETARY SYSTEM. By RICHARD A. PROCTOR, B. A., F. R. A. S. London: Longmans, Green, & Co. New York: Scribner, Welford & Co. For sale by Van Nostrand.

A new book from Mr. Proctor is always acceptable. No other writer of the present day affords us

so satisfactory a discussion of the present condition of astronomical knowledge.

The scientific deductions from late spectroscopic observations, are set forth in the present work in the clearest manner. The method of making the observations has never been so well described before.

The most attractive portion of the book to astronomical students, is, doubtless, that describing the methods of observing the transits of Venus, and the relative value to astronomy of the coming transits of 1874 and 1882.

The book is illustrated with 110 wood-cuts, and 10 lithographic plates, all of which are excellent.

A Complete Guide for Coach Painters. Translated from the French of M. Arlot, by A. A. Fesquet. Philadelphia: Henry Carey Baird. For sale by Van Nostrand.

This little book presents simply the principles which guide the artisan in one of the numerous branches of the art of painting.

As coach painting is a trade of itself, this compilation of technical rules is likely to prove of good service, while the chapters on the preparation of colors and treatment of varnishes will meet the wants of other artisans.

An appendix of 70 pages treats of coach painting as practised in England and the United States.

Elements of Machine Construction and Drawing, or Machine Drawing; with some Elements of Descriptive and Rational Cinematics. By S. Edward Warren, C. E. New York, John Wiley & Son. For sale by Van Nostrand.

This work is on an entirely new plan. Besides affording instruction in methods of machine drawing according to Prof. Warren's admirable method, it affords excellent instruction in the elements of mechanism. This latter branch of science has received too little attention in our technical schools; in fact, it has had none at all; the only instruction obtainable in this department has been that contained in one or two English books, and a few odd chapters in works on Practical Mechanics, and with which latter science Mechanism has been confused.

The methods of transmitting and modifying *motion* without reference to power, is worthy of being considered a subject for study in our schools. That educators are beginning to understand its importance, we see several indications, one of which is a new edition of Willis on Mechanism, and another and more important is this work of Prof. Warren's.

The former is not designed for a school textbook, while the latter, prepared by one of the most skilled instructors in the country, is specially designed for class work.

Prof. Warren's admirable method of classification is well applied to this new subject of scientific study.

The whole subject is divided into two portions or books. Book 1st, treating of simple or single elements of machines; Book 2d, of compound elements or sub-machines. The separate divisions of each book treat of supporters, receivers, communicators, regulators, modulators, and operators.

The slide-valve receives its full share of attention, and the elucidation afforded of its principles of action is an agreeable contrast to some of the late English works on this topic.

The work is abundantly illustrated with wood-cuts, interspersed in the text, and an atlas of folding plates.

Statistics of Mines and Mining in the States and Territories West of the Rocky Mountains. By Rossiter W. Raymond, United States Commissioner of Mining Statistics. Washington: Government Printing Office. 1870. For sale by Van Nostrand.

The second report of Commissioner Raymond is embraced in a volume of 805 pages, embellished with sections of mines and drawings of mining and dressing machinery.

The resources of the following States and Territories are given by counties, and the more important mines and mining sections are reviewed in considerable detail under the head of Part I.: California, Nevada, Oregon, Idaho, Montana, Utah and Arizona, Wyoming, Colorado, New Mexico.

The Commissioner estimates the bullion product for 1869 as follows:

California	$20,000,000
Nevada	14,000,000
Oregon and Washington	4,000,000
Idaho	7,000,000
Montana	12,000,000
Colorado and Wyoming	4,000,000
New Mexico	500,000
Arizona	1,000,000
All other sources	1,000,000
	$63,500,000

The estimated total product for 1868 was $67,000,000. "The falling off is less than the severe drought, affecting the placer mines, the disastrous conflagration in three most important silver mines, and the disturbances caused by miners' strikes in various localities could lead us to expect. In fact, the decrease in the placer product has been partly counterbalanced by an increased yield from quartz mining; and it is especially encouraging that the causes of decrease have been temporary, like a bad season in agriculture, or the accidental destruction of buildings in manufactures, while the causes of increase have been such as may be expected, to operate with augmented effect hereafter. *I cannot but consider the prospects of our mining industry in the precious metals as far more promising than they were a year ago.* One phenomenon, which is almost universal, carries better augury for the future than any number of new and startling discoveries. I refer to the *reduction of wages*, and other items of hitherto unreasonable expense. This relieves mining enterprises from a burden which they have in general not been able to bear, and which has been laid upon no other industry in this country in the "same degree."

Dr. Raymond has availed himself of the services of prominent experts in the different mining sections discussed in his report, and has thus brought together a far larger and more accurate amount of information than could possibly have been obtained by personal observation with the limited time at his disposal.

Mr. Louis A. Garnett has, in a series of articles in the "Alta California," endeavored to prove Dr. Raymond's bullion estimates inaccurate. After a careful perusal of the discussions *pro* and *con*, we cannot see that Mr. Garnett proves his case. Until Government establishes some more perfect system of getting at the bullion product, all estimates must be more or less inaccurate.

In this year's report, much more attention has been given to the States and Territories other than California and Nevada, and it is most gratifying to note the rapid development in the northern Territories notwithstanding the rigors of the climate.

Colorado, although the most accessible of our mining territories, has had more disadvantages to contend with than any other of the mining sections. The disadvantages may be summed up in a few words—mining companies with bogus capital, and wild-cat property; incompetent management in the case of good property; and last, but not least, it has been *cursed with processes.*

The gullibility of Eastern capitalists engendered sharp practice on the part of the original claim owners, coupled with laziness, for it was easier to sell a claim at the East than to work it. During the years of the greatest Colorado excitement there was less gold being produced than during late years, when the production of the precious metals has been dependent almost entirely upon individual enterprise. We find the estimated yield of the precious metals for 1870 to be $4,870,000, over three-quarters of a million more than Colorado and Wyoming *together* for 1869. Another most gratifying development is that of the coal deposits, coal being turned out at the rate of 200 tons per day.

Dr. Raymond, in discussing the condition of affairs in Colorado, puts this whole matter in such an admirable manner, that we feel it our duty to quote at length, and his remarks may be well pondered by all who have or intend having anything to do with mining operations:

"The mines themselves are not to blame. I am sometimes even surprised that they have yielded so much as they have; they will prove equal to those of any other country. Mining is a business full, at best, of difficulties and risks; and it is the part of wisdom to secure at the outset as many of the chances as human foresight can perceive, or human skill control. When a man engages in this business with all the chances against him, it requires no prophet to foretell the result. Among the mines which never did pay, and never will, I unhesitatingly include those that have no existence. There have been in Colorado a great many Hamlets, with Hamlet left out. It need not be said upon what shoulders the blame should fall. Perhaps it is about equally divided. If Eastern speculators have badly burnt their fingers, some of the miners have been well plucked in their turn. It is but seldom that sympathy is required for either side. All speculation aims at getting a thing for less than it is worth, and selling it for more; and pure mining speculation—the system which looks not to the steady development of a country, but to shuffling off the burden of its development upon successive shoulders—is not deserving of success. The purchaser of stock in one of these paper companies is only anxious to raise the value of the stock and get rid of it; and often he is a fool, because he tried to be a knave and failed. It is like the 'pocket-book game' in our Eastern cities. If the stranger upon whom it is tried is a thoroughly honest man, it fails; but if he is just sharp enough to pay twenty dollars for the chance of getting a hundred out of the pocket-book, skilfully left for him to find, he falls a prey to his own acuteness and unscrupulousness, and we do not pity him when his prize turns out to be brown paper, tipped at the end with counterfeit notes."

"To the important questions, 'How came those mines, that once were profitable, to fail? What is the secret of the present success of others? How can many, now idle, be restored to an active and fruitful condition?' There are no general and universal replies. We might as well ask why one merchant fails and another succeeds. Some merchants ruin themselves by their own extravagance and incompetency; some embark in a business in which failure is a foregone conclusion, circumstances being from the outset against them. If we consider, however, the maxim, abundantly illustrated, that bad management will ruin any mine, however valuable it may be, we may say with confidence that bad management has done more to injure mining in Colorado than all other causes together. And this bad management has been fourfold in laws, in the extraction of ores, in the reduction of ores, and in general finance. Here, too, the blame must be divided. Incompetent agents have doubtless wasted money, but they have generally acted under advice. Scientific men, so called, have made stupendous mistakes of judgment; but they have been surpassed by the blunders of practical men, so called. The scientific men without practice, and the practical men without science, the honest men without capacity, and the smart men without honesty, have done so much to destroy the mining industry in Colorado, that the very fact of its continued existence, after so terrible a trial, is proof of its inherent vitality and future prosperity. This year marks the new era of mining in Colorado. The old spirit of idleness and speculation has passed away. The new spirit of labor and economy has sprung into power. It is beginning to be recognized that the men to develop the resources of a country are the men who live in it; that the foundation of wealth is labor, and that only; that capital is only the hoarded labor of the past, loaned to the labor of the future; and that, under all, before all, above all, if there is to be progress, that must be work."

There is much of such forcible argument throughout the report.

Twenty-three pages of the report are devoted to a letter on the United States Mining Law, from the Hon. E. F. Dunne, of White Pine County, Nevada, "whose legal knowledge, as well as his long familiarity with the conditions of tities, etc., of mines on the public lands, entitle his views to the most respectful consideration."

Part III. is devoted to a consideration of mineral deposits, embracing the latest and most advanced views on this subject.

Part IV., on "The Mechanical Appliances of Mining," by W. P. Blake, is probably the most important contribution to this branch of mining industry that has ever appeared in the English language; in fact, it supplies a want that has long been felt in this country, especially by those who have had the instruction of engineers. We are glad to learn that Prof. Blake intends publishing this part separately, for the use of miners, millmen, and students. The fact of Prof. Blake editing the work is a sufficient guarantee of its excellence.

The concluding part of the report is devoted to a short consideration of the newer metallurgical processes used on the Pacific coast. We believe that Dr. Raymond purposes going into this matter very elaborately in a subsequent report.

It is to be hoped that Government will sufficiently appreciate the value of Dr. Raymond's services, to continue this great work from year to

year. The importance of yearly reports upon our mining industry is certainly not second to that of reports upon agriculture.

MODERN PRACTICE OF THE ELECTRIC TELEGRAPH. A Hand-book for Electricians and Operators. By FRANK L. POPE. Fourth edition, revised and enlarged. New York: D. Van Nostrand, 23 Murray street and 27 Warren street.

Although it is less than two years since this work was originally published, it has already become the standard treatise on American telegraphy. For this reason we are glad to see that the enterprising publisher has brought out the present edition in a style much superior to its predecessors, and with corrections and additions which largely increase the practical value of the book. Even within the comparatively short time which has elapsed since this book was first written many new facts in regard to telegraphic practice, which had hitherto escaped notice, have been brought to light by the careful investigations of such men as Farmer and Brooks. This has been noticeably the case with regard to insulation and the arrangement of batteries.

Every year's experience of our best telegraphers is leading them to the inevitable conclusion that the fundamental defect of the whole system—in fact, the root of all the innumerable evils that telegraphs are heir to, is in defective insulation. A quarter of a century has been spent in unavailing efforts to palliate or avoid its effects, while the cause itself remained comparatively untouched. Self-adjusting relays, low resistance relays, enormously heavy conducting wires, and half a hundred other devices have been successively heralded as the great specific remedy; but one by one the intelligent and thinking class of telegraphers are becoming convinced that all this is the merest empiricism and quackery. The disease itself must be rooted out. When our lines are once thoroughly and completely insulated it is an easy matter to dispose of every other difficulty that may arise. That these considerations have not escaped the notice of the author is evident from some changes which have been made in the original text, as well as the character of a portion of the new matter which has been added. Thus, on page 58 of the former editions, we read: "Experiments show that soot will destroy the surface insulation of even the best insulators, unless exposed to the cleansing action of the rain." Two years of experimenting have evidently impressed upon Mr. Pope's mind the undoubted fact that the "cleansing action of the rain" does not help the matter much, for in rain the outer surface of the insulator, though clean, is wet, and therefore a conductor, while the inside is both dirty and wet and also a conductor. He now says, "*even when exposed* to the cleansing action of the rain." An important difference, as will readily be perceived. Again, on page 63, referring to the English system of attaching earth wires to the poles, to cut off cross currents, the old editions remarked that "this practice might be adopted in this country with great advantage to the working of the line." The author has now arrived at the eminently sensible conclusion that, instead of adopting the practice referred to, "a much more economical and effective method of obtaining this result is that of improving the insulation."

Chapter IX is composed entirely of new matter, relating to "Recent Improvements in Telegraphic Practice." Considerable information is given in regard to the newly invented "compound wire," and the "gravity battery," in its different forms. This, we think, is undoubtedly destined to be the universal telegraphic battery of the future, and the author, evidently foreseeing this, has given a concise but correct description of the battery, and directions for its management, which leave little to be desired in this respect. The Siemens Galvanometer, a very recent European invention for testing the lines, etc., is well described, and its principles illustrated. This instrument has met with a remarkable degree of favor in this country, some 15 of them being already in use here with the most satisfactory results, although it is not more than a year since its first introduction. The Pope & Edison type printer, for private telegraph lines—another new and successful invention—is described and well illustrated. Nothing is said about the new Automatic system which is exciting so much interest, probably because its details are not sufficiently complete to admit of a careful description.

A very valuable chapter on "the Equipment of Lines," a much neglected point in scientific telegraphy, has been added to the Appendix, and will excite much attention and perhaps some discussion among those interested. The recommendations contained therein certainly differ very widely in many cases from present practice. The portion relating to the arrangement of sounders and registers, in connection with their batteries, is excellent. The credit of the latter investigation was due originally to Mr. Brooks, and we are glad to find that Mr. Pope has embodied it in a permanent form. "The Working Capacity of Telegraph Lines" is a treatise on insulation in disguise, and a good one, too. There is food for much study and reflection in this article.

We are glad to see Ohm's method of geometrical projection, as applied to telegraphic circuits by Webb, embodied at length in a permanent form. It is curious, interesting, and valuable, and will be better appreciated a few years hence than it is now.

A great defect in the former editions of this work was the lack of an index. This has been supplied in the present one, and it is needless to say adds greatly to its value. These additions and improvements, as well as the handsome style in which the publisher has brought out the work, will no doubt insure it a continued and increased popularity among American telegraphers.—*The Telegrapher.*

METALS, THEIR PROPERTIES AND TREATMENT. By C. L. BLOXAM, Professor of Chemistry in King's College, London; Professor of Chemistry in the Royal Military Academy, and in the Department of Artillery Studies, Woolwich. Pp. 296. (London: Longmans, Green and Co., 1870.) For sale by Van Nostrand.

This is one of the text-books of science which are being edited by Mr. T. M. Goodeve and published by Messrs. Longmans. The series is intended to supply a want that has long been felt of exact and complete works on mechanical and physical science for the use of schools, and for the self-instruction of working men. A difficulty must have been experienced by many who are engaged in teaching science, when asked to recommend a small and inexpensive text-book, which may at the same time be so simply and clearly written as

to be useful to those who have not had a scientific education, and who have not the advantage of being able to attend long courses of lectures. Many popular books on scientific subjects have been written, but they are not unfrequently somewhat inaccurate; difficult questions being often omitted, or, what is, worse, treated in a superficial manner which is likely to mislead the student, inducing him to believe that these questions are very simple, and deluding him with the notion that he knows all about them. He is thus frequently disappointed at a subsequent period by finding that on studying the subject more minutely, it is much more complex than he at first imagined, and that many of the simple ideas which he had carefully fixed in his mind have to be discarded, and new ones acquired.

The book opens with an introductory section on the properties and treatment of metals, containing many useful tables, such as specific gravities, fusing points, conductivity, etc. The more common metals used in the arts are alone discussed so as not to introduce unnecessary complication. The remaining sections of the book treat of iron and steel, copper, tin, zinc, lead, silver, gold, mercury, platinum, palladium, antimony, bismuth, aluminium, magnesium, and cadmium. The last six being far less important than the others, are very shortly described, and only occupy 12 pages.

Each section commences with a description of the ores of the metal under consideration, their composition being given, and also the percentage of metal present. This is followed by the methods of treating the ores in order to extract the metal, chemical reactions being written in words without formulæ, so that no preliminary knowledge is necessary. The mechanical treatment of the reduced metal is then detailed, and its useful applications in the pure condition or in the form of alloys. The book is profusely illustrated with good wood-cuts, and is written in an extremely interesting manner which cannot fail to attract the attention of the student. This, together with the trustworthiness of its contents and its low price, will render the treatise extremely useful for scientific instruction. If the remaining text-books of the series possess all the advantages which are presented by this one, the thanks of teachers and students of science will be due to the editor and publishers for their undertaking.

THE YOUNG MECHANIC, a Book for Boys, containing Directions for the Use of all Kinds of Tools. Trubner & Co., London. For sale by Van Nostrand.

"The Young Mechanic" is a capital book for boys. It contains a large amount of easy and cleverly defined lessons on carpentry, joinery, tin and iron work, soldering, etc., and other subjects of a similar character, starting at the beginning, such as cutting a piece of wood with a knife (a boy's first plaything), up to the practical use of gouges, chisels, and other tools for lathes and machinery, such as are in use by adult mechanics, thus rising step by step from simple experiments to more extensive ones. The author has rendered good service to boys by producing this book, and we hope his reward will be shown by them in purchasing one each, or asking their parents to do so for them as a Christmas present or a New Year's gift. The book is well illustrated, printed in good bold type and on good paper.—*Mechanics' Magazine.*

WHITAKER'S ALMANAC FOR 1871. By J. WHITAKER. London: Warwick lane, Paternoster row. For sale by Van Nostrand.

This is something more than its title indicates. It should have been "Book of Information, with Almanac." The vast amount of particulars set forth in its 300 and odd pages is beyond description. The particulars are in a condensed form, but sufficiently explicit for the purpose. We are unable to identify one page of greater value than another; whether it relates to naval, military, commercial, scientific, statistic, or any other matter, each subject is dealt with with due regard to the interests associated with it. The usual weather and date chart is, of course, given, besides the calendars for high water, church lessons, and astronomical notes.—*Mechanics' Magazine.*

TELEGRAPH HANDBOOK. London: Lockwood & Co., Stationers' Hall Court. (Weale's Rudimentary Series, No, 138.) For sale by Van Nostrand.

"The Telegraph Handbook" is extremely handy, containing, as it does, a large amount of information relating to telegraphy. Its chief purpose appears to be to instruct persons in the official routine of the office. Copies of the usual forms for sending messages are given, and the arrangements and operations of the signalling apparatus are described with clearness, as well as the construction and mode of repairing wires and other delicate parts of the instruments. Telegraphy is becoming a trade or profession in the hands of the Post Office authorities; and the staff of female clerks they employ, and those under probation, will find this book of great value towards educating them for their duties.

MISCELLANEOUS.

A NEW CEMENT.—In the specification of a recent French patent granted to Mr. A. Warner, of London, he claims a new cement, composed in part of silicate of iron (preferably obtained from the scorious product of iron manufacture), or of oxides of iron or iron ore combined with sulphate of lime in proper proportions. To the latter, silex can be added. To give the cement the greatest durability for out-door work, Mr. Warner employs the determined proportions of the soluble phosphates, acids, or other chemical equivalents.

Practically the manufacture of this cement consists in reducing to fine powder, *laitier* (dross), or scoria, and thoroughly blending it in an ordinary flour mill with sulphate of lime, which has been mixed with a previously certain quantity of soluble phosphate. The proportions should be varied in accordance with the intended use of the cement.

The following are suggested: 700 parts calcined sulphate of lime, 200 silicate or oxide of iron, or iron ore, 2½ soluble phosphate of lime.

Superphosphate of lime may be used in place of soluble phosphate, and in this case equal quantities of superphosphate and silicate or oxide of iron must be employed. Phosphoric or boric acid may be substituted for the soluble phosphate in the proportion of 6, 10, or 14 parts (according to strength) to 300 silicate of iron. And again, any phosphoric or boric salt, or indeed any chemical equivalent capable of forming a cementing sub-

stance when combined with silicate of iron, with or without the addition of sulphate of lime, may be substituted for the phosphoric or boric acid. When the cement is made without sulphate of lime, it is well to use a larger proportion of soluble phosphate of lime.

The above mentioned substances being intimately mixed in powder, there only needs sufficient water to make the cement of the necessary consistency for the purpose.—*Le Genie Industriel de Paris, through Am. Railway Times.*

A NEW DANGER TO OCEAN CABLES.—The submarine cable of the International Telegraph Company, between Punta Rosa and Key West, has been so frequently broken and injured during the past year, that Col. Heiss, the superintendent of the line, determined to ascertain the cause of these accidents; and from frequent and careful examinations of the iron at the points where it was crushed or broken, he has been forced to the conclusion that the damage has been done by the loggerhead turtles which abound in these waters. In many places the cable presented an appearance which indicated the belief that it had been bitten through, and in others of having been crushed from both sides until it was flattened so as to destroy its conductivity and interrupt communication; and as the breaks and injuries have been found at the depth of water in which turtles most abound, no other cause is known to which the injuries are attributable The conclusions of Col. Heiss are rendered the more probable by the fact that the loggerheads are noted for the great power of their jaws, with which they crush conch-shells and almost anything else which comes within their reach. This is certainly an unforeseen source of danger to which telegraph cables in tropical waters are subjected, and one for which provision will have to be made. The International Company, whose line has been so badly chewed up by the turtles, have sent an order to this city for a much larger and stronger cable, and when it is laid the turtles will have something more substantial than the present steel-wound cable to whet their teeth upon.—*Iron Age.*

SAYS the St. Louis "Times:" The Miss. Val. Trans. Co. has a contract with the State of Illinois to transport the iron for the dome of the new Capitol. The pieces are cast at Antwerp, transported to New Orleans, and unloaded upon the barges. Each piece weighs 10 tons, and the contract is for 10,000 tons.

THE NINTH CENSUS COMPLETE.—The following table, prepared by the Census Bureau at Washington, gives the total population of all the States and Territories of the Union, by the enumeration of 1870, as compared with that of 1860. Several statements, purporting to give the result of the last census, have been floating through the newspapers, but this is the first that has appeared with the official sanction. It will be seen that the total population of the United States in 1870 was 38,538,180—an increase in 10 years of 7,094,859. This increase is not so much as was generally expected, but when it is considered that the great civil war of the last decade swept away several hundred thousand citizens, and that, perhaps, as many emigrants from abroad were discouraged from coming to our shores from the same cause, the country has really been doing very well. The greatest percentage of increase is in Nevada, and after it Nebraska. Two States only exhibit a decrease—Maine and New Hampshire. All the Western States show heavy percentages of increase, the Southern and Middle States a small increase, while New England is almost at a stand-still. The table is interesting and instructive:

States.	1870.	1860.	Gain, per ct.
Alabama	996,988	964,201	3.5
Arkansas	483,179	435,450	11
California	560,285	279,984	47.5
Connecticut	537,418	460,147	16.8
Delaware	125,015	112,216	11.5
Florida	187,756	140,424	38.8
Georgia	1,200,609	1,057,286	13 6
Illinois	2,589,638	1,711,951	48.4
Indiana	1,663,046	1,350,428	23.9
Iowa	1,191,802	674,913	76 6
Kansas	362,872	107,206	238 5
Kentucky	1,321,001	1,155,684	14.4
Louisiana	732,731	708,002	3.5
Maine	626,463	628,279	*.29
Maryland	780,806	687,049	13.7
Massachusetts	1,457,351	1,231,066	18 4
Michigan	1,184,296	749,113	58.1
Minnesota	435,511	172,023	153.2
Mississippi	834,170	791,302	5.5
Missouri	1,715,000	1,182,012	45.1
Nebraska	128,000	28,841	226 5
Nevada	42 491	6,857	519.7
New Hampshire	318,300	326.073	*2.4
New Jersey	905,794	672,055	34 8
New York	4,364,411	3,880.735	12,5
North Carolina	1,069 614	992,622	7 8
Ohio	2,662,214	2,339.511	13 8
Oregon	90,922	52,465	73.4
Pennsylvania	3,515,993	2,906,215	21
Rhode Island	217,356	174,620	24.5
South Carolina	728,000	703,708	3.5
Tennessee	1,257,983	1,109,801	13.4
Texas	797,500	604,215	32
Vermont	330,552	315,098	5
Virginia	1,224,830	1,219,630	.43
West Virginia	445.616	376,688	18 3
Wisconsin	1,055,167	775,881	36
Total	38,095,680	31,183,744	21.1
District of Columbia	131,706	75,089	75.5
Territories.			
Arizona	9,658	....	....
Colorado	39,706	34,277	15.9
Dakota	14,181	4,837	193.2
Idaho	14,998	....	....
Montana	20,594	....	....
New Mexico	91,852	93,516	*1 8
Utah	80,786	40,273	115.6
Washington	23,901	11,594	106 2
Wyoming	9,118		....
Total District and Territories	442,500	259,577	
Total of States	38,095,680	31,183,744	21.1
Total United States	38,538,180	31,443,321	22.6

—*Iron Age.*

THE BELGIAN IRON TRADE.—The iron and pig-iron trades of Belgium are feeling the adverse influence of the unexpected prolongation of the Franco-German war. New contracts remaining in suspense; prices are falling, notwithstanding the general confidence which is felt in a revival of activity on the conclusion of peace.

THE use of the new Beton Coignet, for building purposes, is rapidly extending.

* Loss.